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DAMPING CHARACTERISTICS OF 185-INCH 'VITSS' AND STANDARD SONAR --ETC(U)

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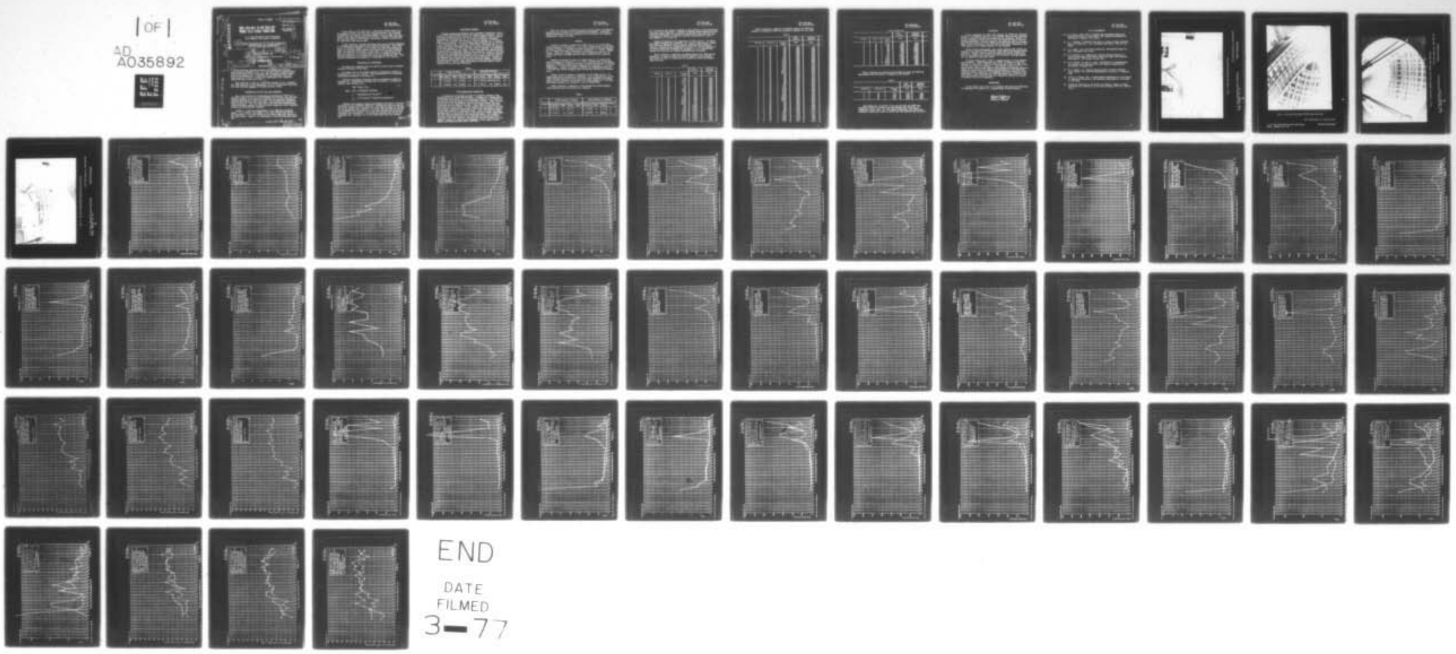

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USL Problem No.
1-650-02-00

U. S. Navy Underwater Sound Laboratory
Fort Trumbull, New London, Connecticut

DAMPING CHARACTERISTICS OF 185-INCH VITSS AND STANDARD SONAR DOME STRUCTURES

By

Howard N. Phelps, Jr

12 58p.

USL Technical Memorandum No. 2133-1213-66

8 December 1966

USL-TM-2133-1213-66

INTRODUCTION

This technical memorandum presents the damping and vibration charateristics, measured in air, of a 185-inch Variable-Internal-Truss-Sizes-and-Spacing (VITSS) steel sonar dome structure, without window. Results are compared with a standard 185-inch CW554/SQS steel sonar dome structure, without a window. The measurements were conducted between May 1964 and October 1964.

When reference is made to a VITSS dome structure or to a standard type dome structure in this memorandum, it is to be understood that each is a dome structure without an attached acoustic window.

DESCRIPTION OF THE VITSS DOME STRUCTURE

One of the objectives in designing and building the VITSS was to determine whether or not the use of stiffeners of various sizes and with variable spacings would reduce the vibration and resulting internally-radiated sound levels of the sonar dome. The structure was intended to reduce self-noise. The first step was to have the VITSS structure constructed without a window, to allow practical comparison with a standard window-less CW554/SQS dome structure.

Figures 1, 2 and 3 are photographs of the VITSS dome structure. Figure 1 is an overall view; Figure 2 is a view looking into the aft end; and Figure 3 is a view looking at the bottom frame just forward of the baffle plate. Figure 4 is a photograph of the CW554/SQS dome structure.

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In the design of the VITSS dome, a particular integer from 0 to 9 was assigned to both a rod size and a spacing distance. By following consecutively the readout of variable numbers out of a table, the consecutive rod sizes and spacings were obtained. Circular rods were used for the outer chords of each truss, and vertical plates 1/4-inch thick by 1-inch wide, were used as webs.

Another objective, although mentioned, may not be covered completely in the experiments discussed in this technical memorandum. This objective is to discover whether or not variable rod sizes and spacing will reduce or eliminate echoes induced by ensonification of the stiffening rods. The bars can be involved in three ways: (1) excitation of the bars into vibration, (2) grating effect, and (3) specular reflections from the scattering of the sound waves from rigid stiffening rods. More detailed discussions are presented in references (a), (b), and (c).

DESCRIPTION OF EXPERIMENTS

The domes were suspended from two hoists by nylon ropes to provide vibration isolation of the domes.

The method used in the damping studies is discussed in detail in references (d), (e), (f), and (g). The instrumentation was calibrated using methods discussed in reference (e).

Vibration measurement techniques used are discussed in detail in reference (d). Accelerations measured were converted to acceleration decibels (see reference (h)).

$$adB = \text{Log}_{10}\,(a/a_o) \qquad (1)$$

where adB = acceleration decibels

a = acceleration in cm./sec.^{2}

$a_o = 10^{-3}$ cm./sec.^{2} (reference acceleration)

Vibration and vibration damping measurements were made on the dome structures at four different locations. Counting aft from the vertical rod at the forward end of the dome, and down from the flange of the dome for the horizontal rods, location 1 is on the 16th vertical rod and the 1st horizontal rod; location 2 is on the 18th vertical rod and the 8th horizontal rod; and location 3 is at the 8th vertical rod and the 4th horizontal rod. Location 4 is on the flange above the 14th vertical rod.

Letter on file

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PRELIMINARY RESULTS

Vibration damping measurements were performed at locations 1 and 2 of the VITSS dome structure and of the standard dome structure. For the VITSS dome structure and at locations 1 and 2, Figures 5 and 6 present, respectively, the decay rate vs. 1/3 octave band center frequency; figures 7 and 8 present the percent of critical damping vs. 1/3 octave band center frequency. For the standard dome structure and at locations 1 and 2, Figures 9 and 10 present, respectively, the decay rate vs. 1/3 octave band center frequency; Figures 11 and and 12 present the percent of critical damping vs. 1/3 octave band center frequency. On completion of the analysis of the data taken, it was noted that the damping characteristics of the VITSS dome structure were inferior to those of the standard 185-inch CW554/SQS dome structure; that is, the vibrations induced by impact on the VITSS dome structure did not decay as fast as those of the standard dome structure when it was excited by impact. Testing of the dome was halted after this comparison was made because of the unexpected results. Table I shows the maximum and minimum damping characteristics of the two dome structures.

TABLE I

	VITSS Structure					CW554/SQS Structure				
Location	Fig. No.	%C/Cc (Min)	Frequency (kHz)	%C/Cc (Max)	Frequency (kHz)	Fig. No.	%C/Cc (Min)	Frequency (kHz)	%C/Cc (Max)	Frequency (kHz)
1	6	.0020	16.0	.0700	0.2	10	.030	1.25&6.40	.185	4.0
2	7	.0025	16.0	.0435	0.5	11	.033	1.25	.365	3.2

VITTS MANUFACTURE CORRECTIONS

An inspection of the dome was made for possible defects in the manufacture of the VITSS dome structure. Although not a design defect, it was found that several of the longitudinal trusses in the bottom of the dome had not been welded to the transverse trusses. Thus, the ends of the rods of the longitudinal trusses were being excited into free vibrations when the dome was excited. Other bottom truss parts were also found to be not welded. It was apparent that the ends of the rods when excited, vibrated as cantilevers, while the intermediate sections of the rods vibrated as fixed-fixed beams. These free ends and other unwelded parts on the bottom frame of the dome were welded, eliminating the free ends and making the rods fixed-fixed beams. The lengths of the other fixed-fixed sections were shortened by welding the intersections of the rods together, increasing the natural frequency of all modes of vibration to some extent, depending on the length of each section and cross-sectional area of the rod.

After the ends and intermediate points had been welded, the damping experiments were repeated, with considerable improvement. Vibration-damping experiments were then conducted at four locations and vibration experiments at three locations.

RESULTS

Figures 13 through 16 present the decay rate vs. 1/3 octave band center frequency for locations 1, 2, 3, and 4, respectively, of the VITSS structure; Figures 17 through 20 present the percent of critical damping vs. 1/3 octave band center frequency for locations 1, 2, 3 and 4, respectively. Figures 21 through 23 present the acceleration level vs. 1/3 octave band center frequency when the dome is excited with a constant force.

Figures 24 through 27 present the decay rate vs. 1/3 octave band center frequency for locations 1, 2, 3 and 4, respectively, of the standard dome structure; Figures 28 through 31 present the percent of critical damping vs. 1/3 octave band center frequency for locations 1, 2, 3 and 4, respectively. Figures 32 through 34 present the acceleration level vs. 1/3 octave band center frequency when the dome was excited with constant force.

Figures 35 and 36 present a comparison of the decay rate vs. 1/3 octave band center frequency for locations 1 and 2, respectively, on the VITSS structure before and after the bottom frame trusswork was welded; Figures 37 and 38 present the percent of critical damping vs. 1/3 octave band center frequency for locations 1 and 2, respectively.

Table 2 presents a comparison of the maximum and minimum damping before and after the truss welds were completed.

TABLE 2

	VITSS Structure (Welded)					VITSS Structure (Unwelded)				
Location	Fig. No.	%C/c (Min)	Frequency (kHz)	%C/c (Max)	Frequency (kHz)	Fig. No.	%C/c (Min)	Frequency (kHz)	%C/c (Max)	Frequency
1	16	.02	2	.92	.1	6	.002	16	.07	.2
2	17	.01	3.2	.395	5	7	.0025	16	.0435	.5

It is noted that the change in damping is much greater at some frequencies than many other frequencies. Although the damping characteristics of the completely welded dome are superior in almost every case, they are best at frequencies between 3.2 kHz and 8 kHz for both locations 1 and 2. (See Figures 6, 7, 16 and 17.)

Figures 39 through 42 are comparisons of decay rate vs. 1/3 octave band center frequency for locations 1, 2, 3 and 4, respectively, between the VITSS dome structure and the standard CW554/SQS dome structure. Figures 43 through 46 are comparisons of percent of critical damping vs. 1/3 octave band center frequency for locations 1, 2, 3, respectively, between the VITSS and the standard CW554/SQS dome structures.

Table 3 presents a comparison of damping between the VITSS and the standard at frequencies where the VITSS is superior to the standard. Care should be taken in recognizing the location at which the measurements were made.

TABLE 3

			VITSS Structure	CW554/SQS Structure
Location	Figure No.	Frequency (kHz)	%C/Cc	%C/Cc
1	42	.100	.9200	.1350
1	42	5.000	.2350	.0650
1	42	6.400	.1900	.0300
1	42	10.000	.0900	.0700
2	43	.100	.3125	.0975
2	43	.125	.1375	.0725
2	43	.160	.1025	.0825
2	43	5.000	.3920	.1025
2	43	6.400	.1375	.0475
3	44	.100	.2100	.0825
3	44	.125	.2525	.0830
3	44	.640	.0500	.0460
3	44	6.400	.0575	.0410
3	44	8.000	.0580	.0440
3	44	10.000	.0750	.0375
3	44	12.500	.1175	.0730
3	44	16.000	.1200	.0460
4	45	.100	8.0000	———
4	45	.125	5.7500	.6000
4	45	.640	3.0000	2.6500
4	45	1.250	2.1000	1.5500
4	45	1.600	1.2500	.8200
4	45	2.000	1.3600	1.1500
4	45	4.000	1.0500	.4600
4	45	5.000	1.1600	.5500
4	45	6.400	1.1200	.8000
4	45	8.000	.6500	.3500

Table 4 presents a comparison of damping between the VITSS and standard at frequencies where the standard is superior to the VITSS.

TABLE 4

			VITSS Structure	C[illegible]554/SCS Structure
Location	Figure No.	Frequency (kHz)	%C/Cc	%C/Cc
1	42	.200	.0500	.1100
1	42	.250	.0500	.1100
1	42	.320	.0500	.0750
1	42	.400	.0400	.0900
1	42	.500	.0350	.0700
1	42	.640	.0300	.0700
1	42	.800	.0300	.0700
1	42	1.000	.0300	.0700
1	42	1.250	.0300	.0350
1	42	1.600	.0300	.0500
1	42	2.000	.0250	.0700
1	42	2.500	.0700	.0900
1	42	3.200	.0700	.0900
1	42	4.000	.1300	.1800
1	42	8.000	.0300	.0500
1	42	12.500	.0300	.0700
1	42	16.000	.0300	.1100
2	43	.200	.0500	.0920
2	43	.250	.0400	.1470
2	43	.320	.0450	.1230
2	43	.400	.0400	.0670
2	43	.500	.0370	.0680
2	43	.640	.0320	.0720
2	43	.800	.0300	.0620
2	43	1.000	.0320	.0480
2	43	1.600	.0300	.2180
2	43	2.000	.0230	.1430
2	43	2.500	.0200	.0960
2	43	3.200	.0080	.3320
2	43	4.000	.0480	.2340
2	43	8.000	.0250	.0400
2	43	10.000	.0200	.0670
2	43	12.500	.0170	.0920
2	43	16.000	.0200	.0880
3	44	.160	.0630	.1150
3	44	.200	.0930	.1540
3	44	.250	.0630	.1480
3	44	.320	.0670	.0980
3	44	.400	.0420	.0820
3	44	.500	.0350	.0580
3	44	.800	.0300	.0670
3	44	1.000	.0230	.0730
3	44	1.250	.0220	.0680
3	44	1.600	.0270	.0840
3	44	2.000	.0230	.0920
3	44	2.500	.0420	.1150
3	44	3.200	.0300	.0820

TABLE 4 (Continued)

			VITSS Structure	CW554/SCS Structure
Location	Figure No.	Frequency (kHz)	%C/Cc	%C/Cc
3	44	4.000	.1750	.5750
3	44	5.000	.0430	.0920
4	45	.160	1.2000	1.4500
4	45	.200	.4200	3.6500
4	45	.250	.3800	3.8500
4	45	.320	.4200	1.5500
4	45	.400	.2500	.8200
4	45	.800	1.1500	2.1500
4	45	1.000	1.3300	3.6500
4	45	2.500	.7500	1.0500
4	45	3.200	1.1000	1.7500
4	45	10.000	.3500	.5200
4	45	12.500	.3500	.6000
4	45	16.000	.5500	.6000

Table 5 presents the locations and frequencies where the VITSS had approximately the same amount of damping as the standard.

TABLE 5

			VITSS Structure	CW554/SCS Structure
Location	Figure No.	Frequency (kHz)	%C/Cc	%C/Cc
1	42	.125	.1100	.1100
1	42	.160	.1300	.1300
2	43	1.250	.0375	.0375
4	45	.500	.5000	.5000

From Figures 47, 48 and 49, it can be seen that the VITSS dome structure is easier to excite than the standard dome structure at frequencies below 1 kHz. At a few higher frequencies, the VITSS dome structure is generally harder to excite than the standard dome structure.

DISCUSSION

If all frequencies are taken into account, the VITSS dome structure appears to be slightly inferior to the standard 185-inch dome structure, as far as vibration damping characteristics are concerned. However, at certain frequencies (5 kHz and 6.4 kHz), the VITSS has better (but not considerably better) vibration damping characteristics than the standard. Also, at other locations on the dome and at some other frequencies, the VITSS appears to be slightly superior to the standard.

During initial measurements, this writer believed that welding the trusses at the bottom of the structure would improve the damping characteristics. Indeed, welded trusses did reduce the extent to which the ends of the trusses were excited into free vibration, although damping was not improved to any great extent.

At certain frequencies, VITSS is slightly superior to the standard dome structure. These frequencies are 5 kHz, 6.4 kHz and 10 kHz for location 1; 5 kHz and 6.4 kHz for location 2; and 4 kHz, 6.4 kHz, 8 kHz, 12.5 kHz and 16 kHz for location 3. The addition of more 1/4" x 1" plates between truss chords might possibly improve the damping characteristics to a point where the damping characteristics of the VITSS dome structure might be superior to the standard type dome structure at more frequencies. This would make the VITSS more rigid and, therefore, the dome, when excited, would not have the tendency to vibrate to as great an extent at the lower frequencies.

CONCLUSIONS

At the present time, there is no evidence that shows the VITSS-type of structure to be superior to a standard-type of dome structure.

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Mechanical Engineer

LIST OF REFERENCES

(a) M. F. Borg, "Some Views on Research and Development Efforts at USN/USL Pertaining to Sonar Domes", USL Technical Memorandum No. 933-026-64, 3 February 1964 (Conf.)

(b) C. J. Burbank, "Transducer Dome Bars as a Cause of Sonar Spoking", NEL, R & D Report No. 1146, 6 November 1962 (Conf.) USL Acc. No. 38048.

(c) O. H. Hahs, "Sonar Self-Noise Reduction", USL Research Report No. 462, 20 December 1959 (Conf.)

(d) H. N. Phelps, Jr., "Damping and Vibration Characteristics of a 185-Inch Sand Damped CW554/SQS-4 Steel Sonar Dome, USL Technical Memorandum No. 933-182-64, 26 June 1964.

(e) H. N. Phelps, Jr. and M. F. Borg, "Calibration of Instrumentation for Vibration and Damping Tests", USL Technical Memorandum No. 933-236-63, 22 August 1963.

(f) H. N. Phelps, Jr., "Damping Characteristics of Three Untreated Steel Plates", USL Technical Memorandum No. 933-54-64, 17 February 1964.

(g) LTJG J. E. Barger, USN, "An Experimental Determination of the Degree of Damping of Structures", USL Technical Memorandum No. 1210-94-59, 17 June 1959.

(h) "Units for Vibration in the Field of Acoustics", Bureau of Ships, ALL/NOISE (371), EN8/A2-6, Ser 371-526, 8 October 1951 (Acc. #10135-13-A).

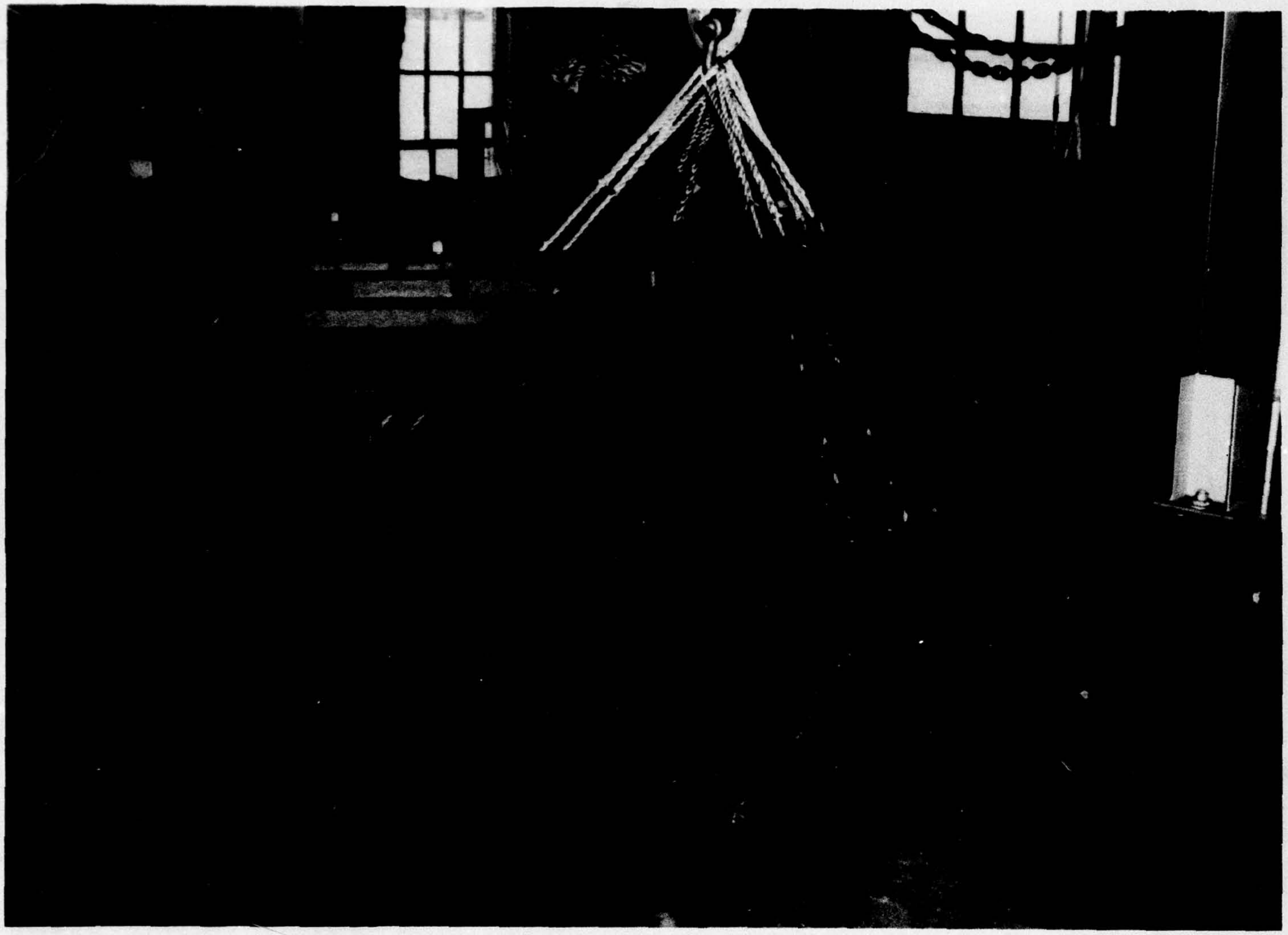


Fig. 1 - 185-inch VITSS Dome Structure

USL Tech Memo No. 2133-1213-66

U. S. Navy Underwater Sound Laboratory
NP24 - N29433 - 12 - 66

Official Photograph

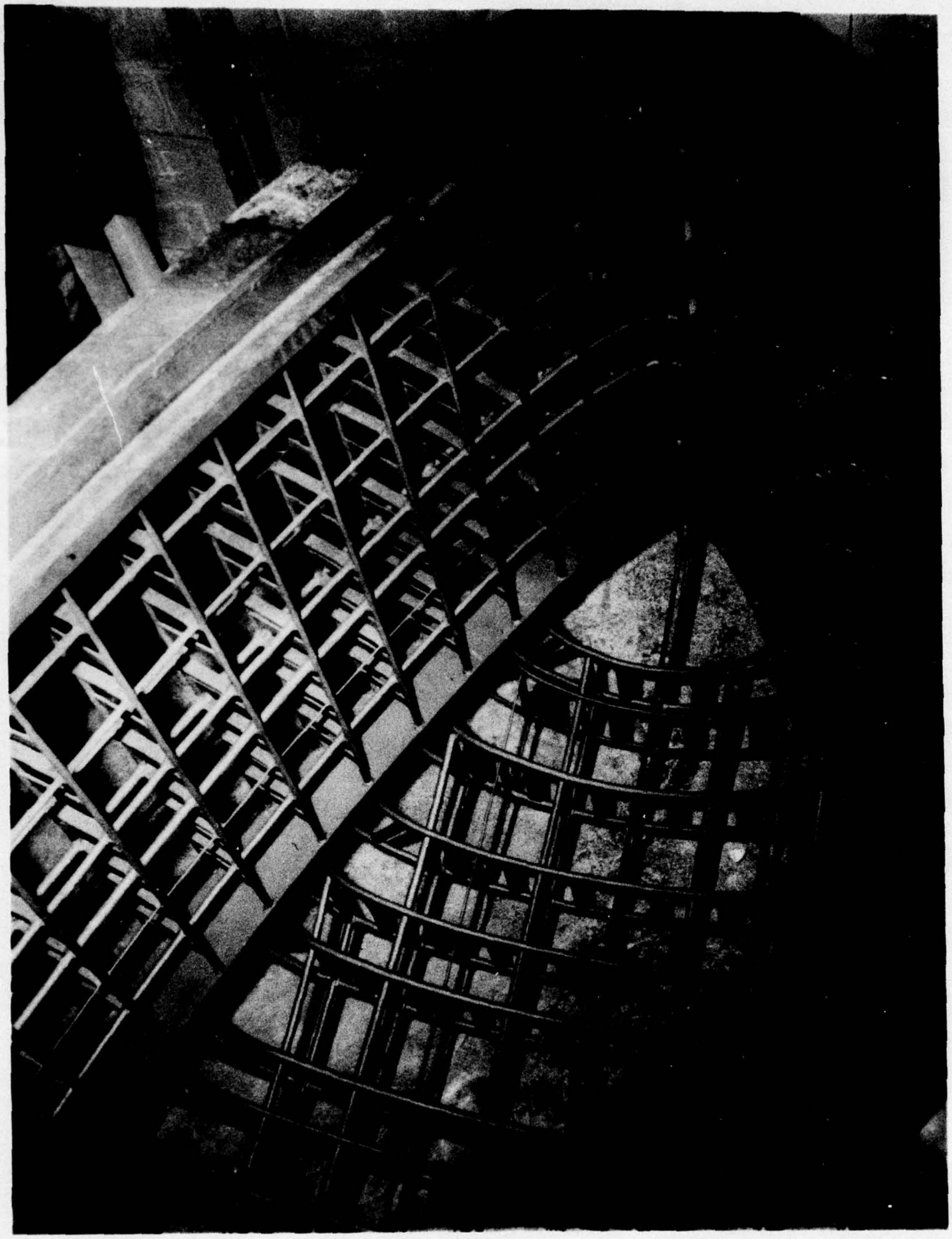


Fig. 2 - Aft End of 185-inch VITSS Dome Structure

USL Tech Memo No. 2133-1213-66

U. S. Navy Underwater Sound Laboratory
NP24 - N29434 - 12 - 66

Official Photograph

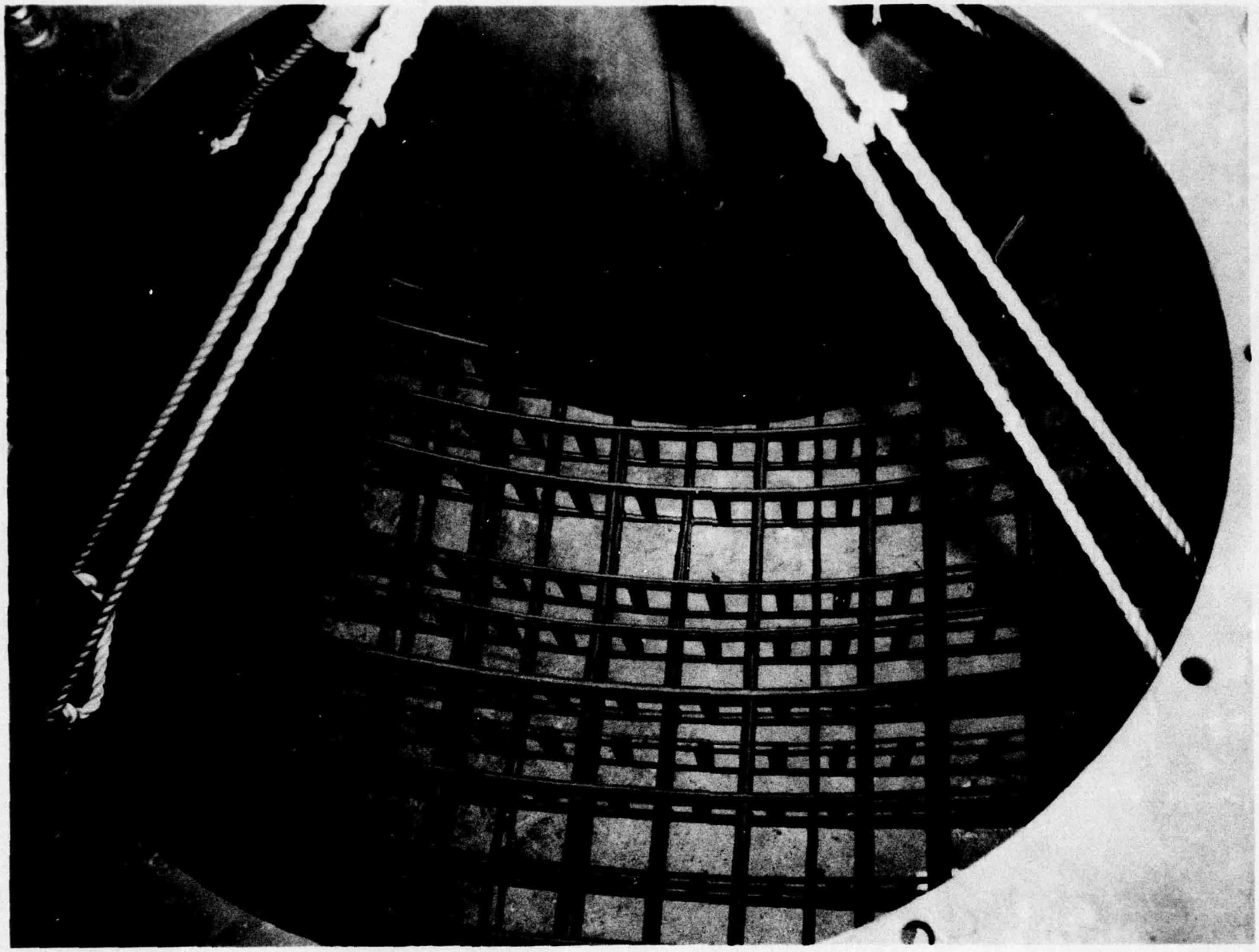


Fig. 3 - Forward of Baffle in 185-inch VITSS Dome Structure

USL Tech Memo No. 2133-1213-66

U. S. Navy Underwater Sound Laboratory
NP24 - N29435 - 12 - 66

Official Photograph

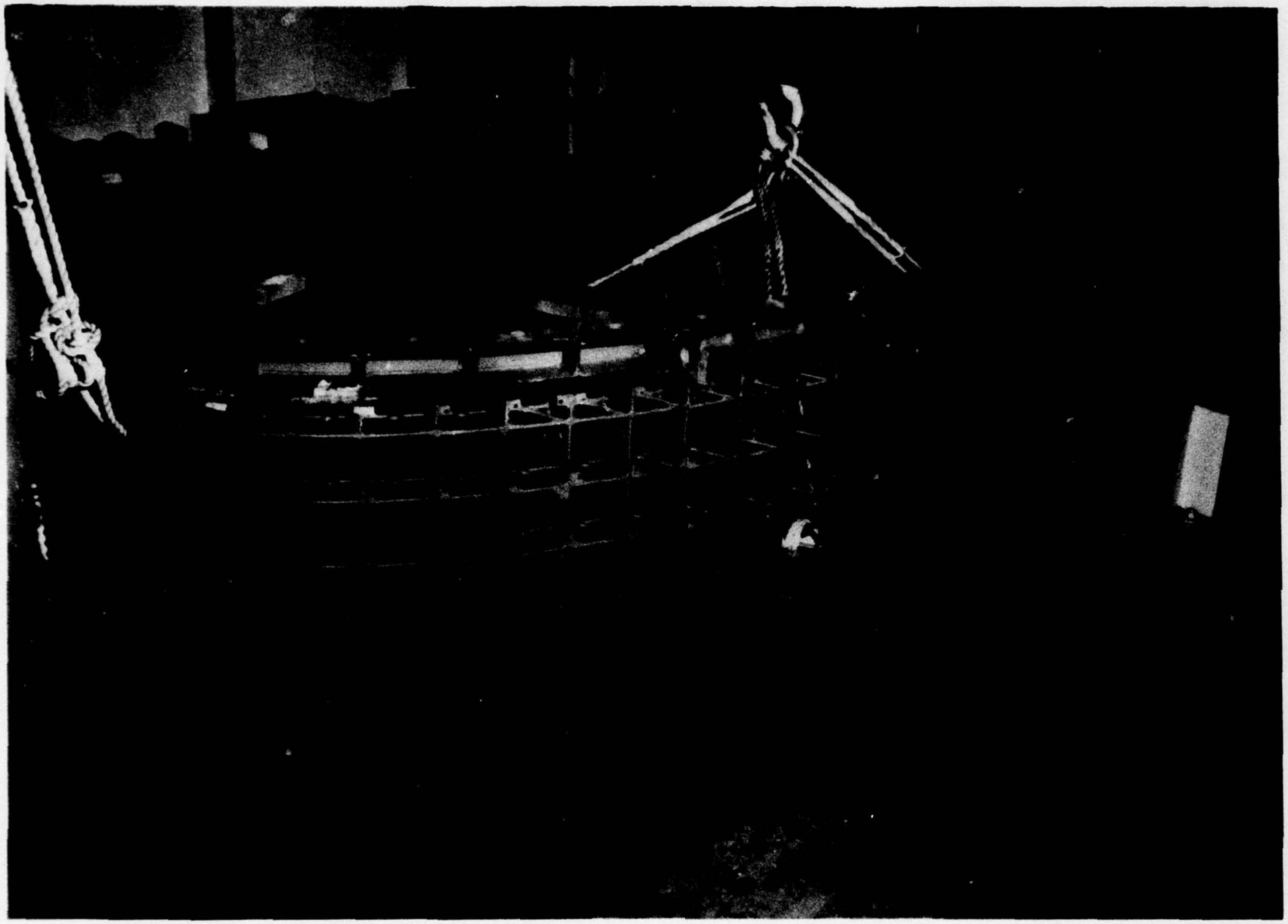
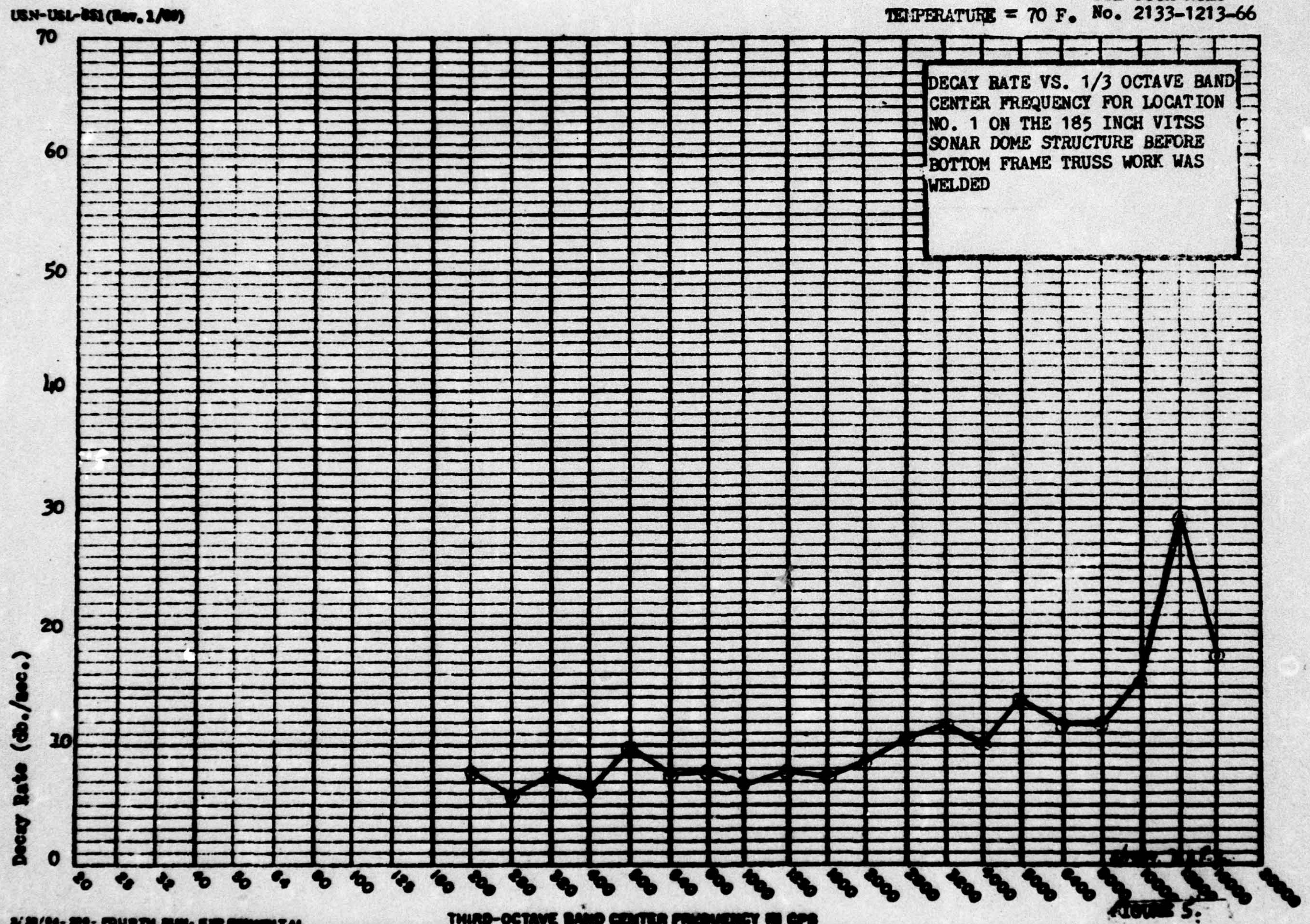


Fig. 4 - 185-inch CW554/SQS Standard Dome Structure

USL Tech Memo No. 2133-1213-66

U. S. Navy Underwater Sound Laboratory
NP24 - N29436 - 12 - 66

Official Photograph


USN-USL-851(Rev.1/60)
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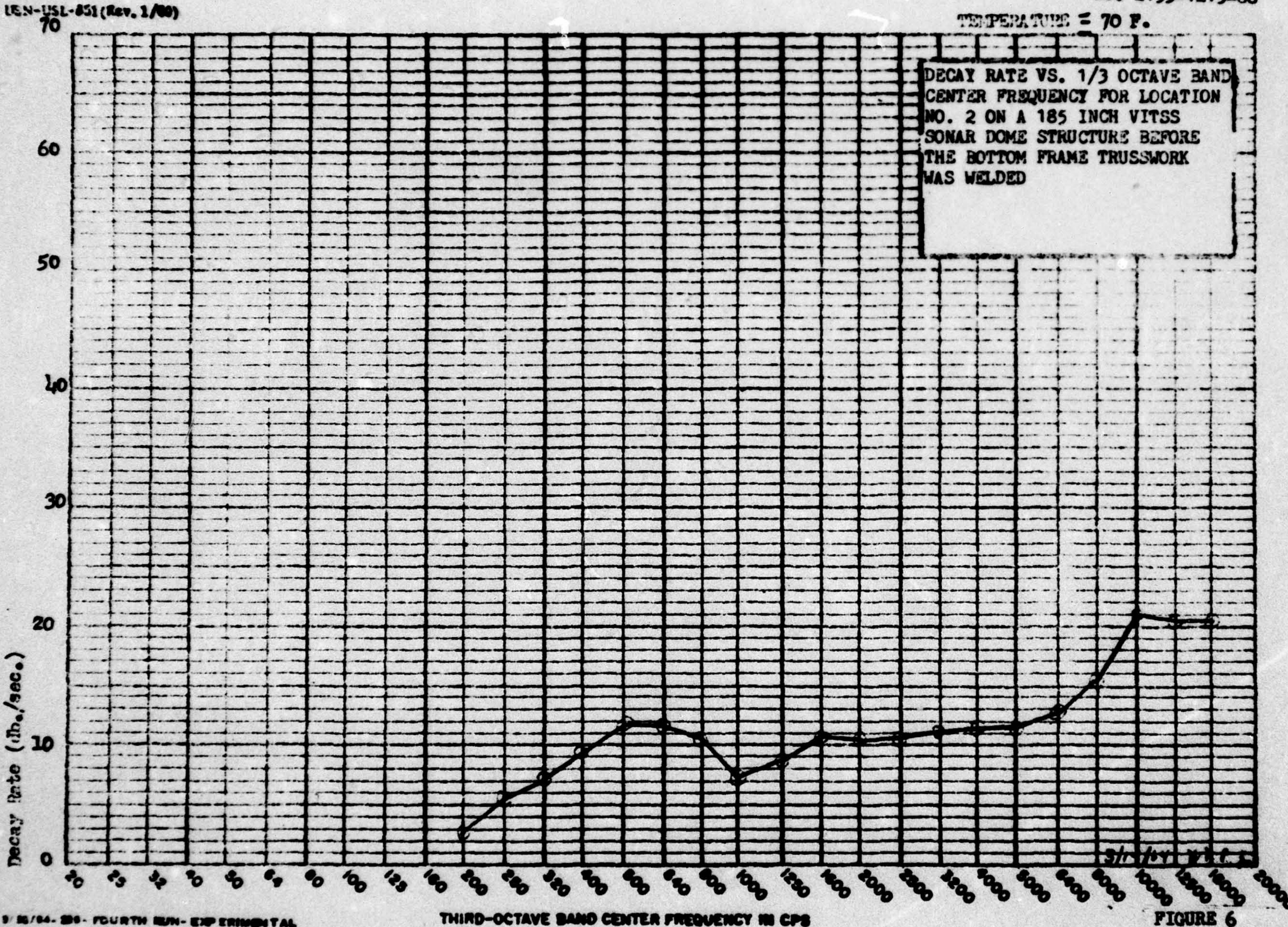
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 1 ON THE 185 INCH VITSS SONAR DOME STRUCTURE BEFORE BOTTOM FRAME TRUSS WORK WAS WELDED
70
60
50
40
30
20
10
0
Decay Rate (db./sec.)
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS

FIGURE 5.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DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 ON A 185 INCH VITSS SONAR DOME STRUCTURE BEFORE THE BOTTOM FRAME TRUSSWORK WAS WELDED
Decay Rate (db./sec.)
0
10
20
30
40
50
60
70
20 25 32 40 50 64 80 100 125 160 200 250 320 400 500 640 800 1000 1250 1600 2000 2500 3200 4000 5000 6400 8000 10000 12500 16000 20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS

FIGURE 6

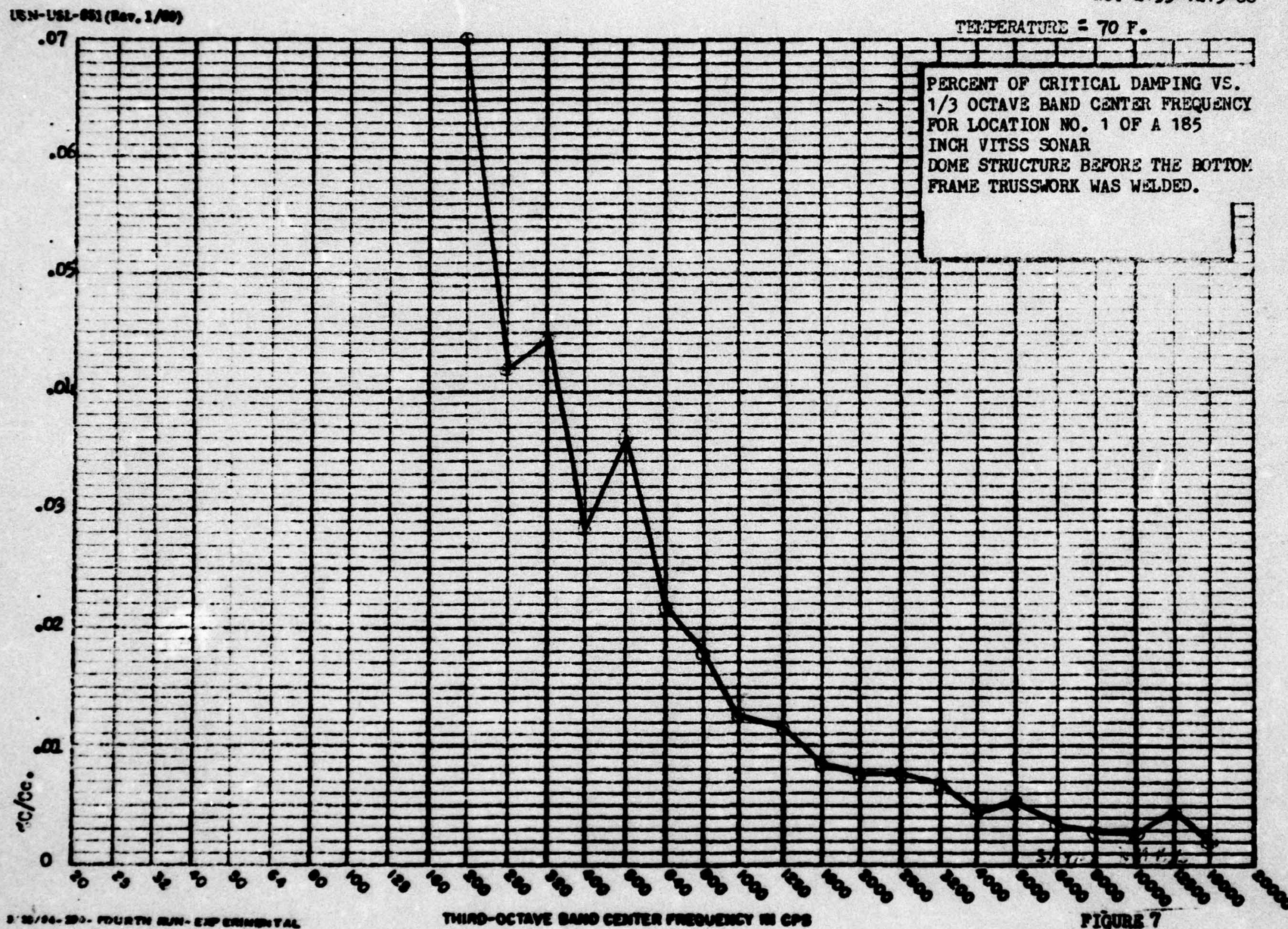

USN-USL-651 (Rev. 1/60)
TEMPERATURE = 70 F.
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 1 OF A 185 INCH VITSS SONAR DOME STRUCTURE BEFORE THE BOTTOM FRAME TRUSSWORK WAS WELDED.
.07
.06
.05
.04
.03
.02
.01
0
C/Cc.
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS

FIGURE 7

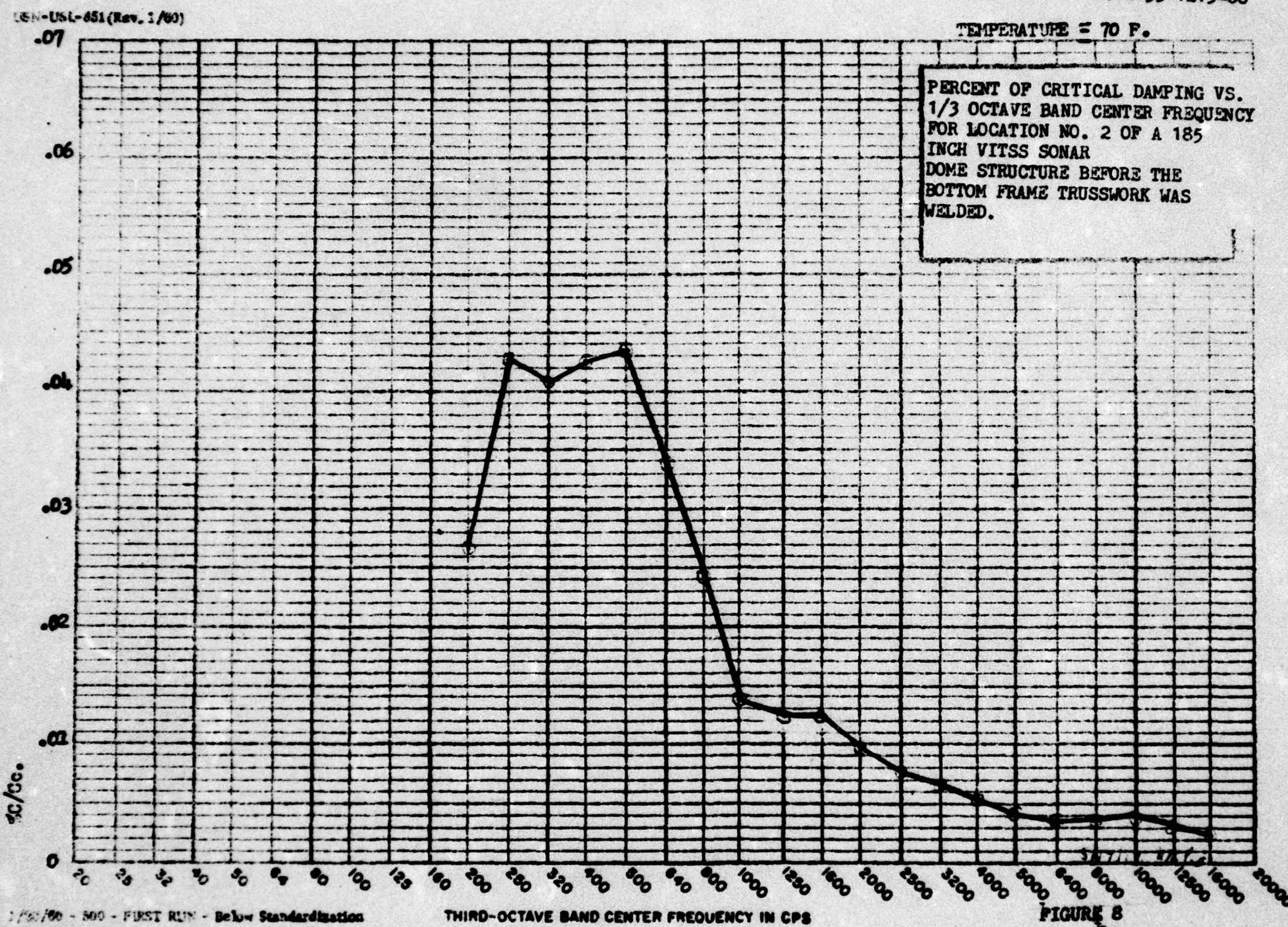

USN-USL-651(Rev. 1/60)
TEMPERATURE = 70 F.
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 OF A 185 INCH VITSS SONAR DOME STRUCTURE BEFORE THE BOTTOM FRAME TRUSSWORK WAS WELDED.
%C/Cc.
.07
.06
.05
.04
.03
.02
.01
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
500 - FIRST RUN - Below Standardization

FIGURE 8

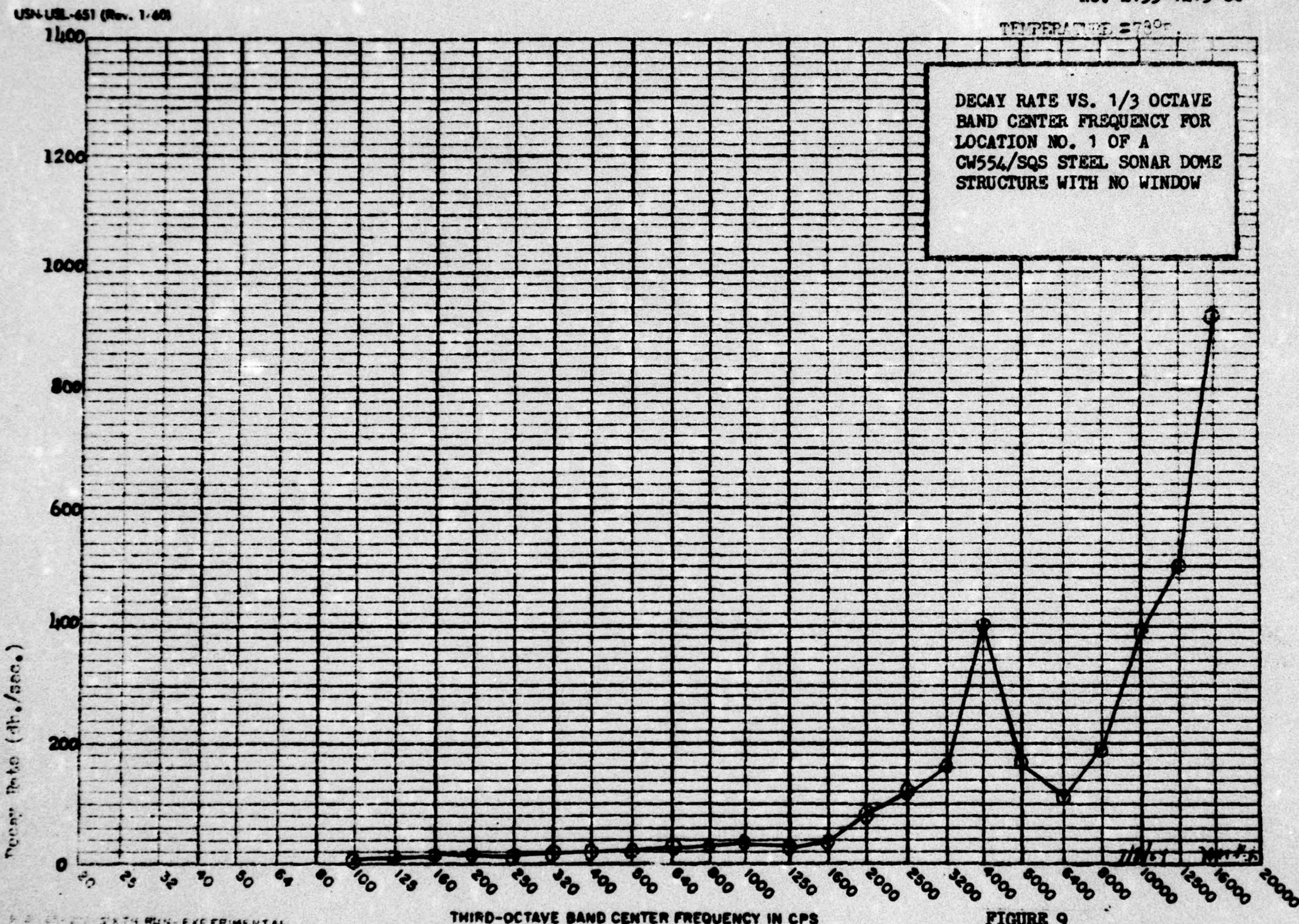
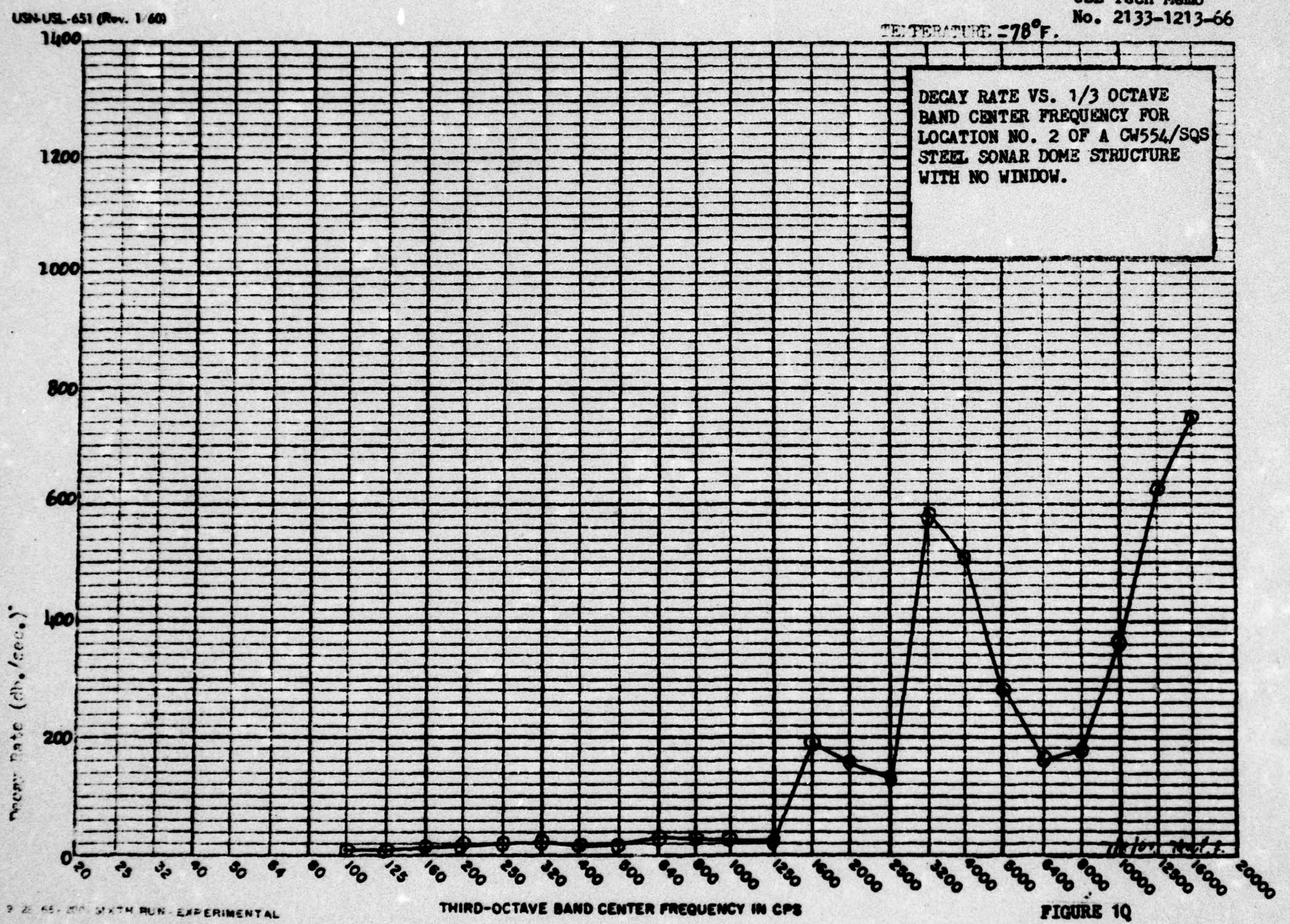

USN-USL-651 (Rev. 1/60)
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 1 OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW
1400
1200
1000
800
600
400
200
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
SIXTH RUN-EXPERIMENTAL

FIGURE 9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DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW.
Decay Rate (db./sec.)
0
200
400
600
800
1000
1200
1400
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
9-26-65-200 SIXTH RUN-EXPERIMENTAL

FIGURE 1Q

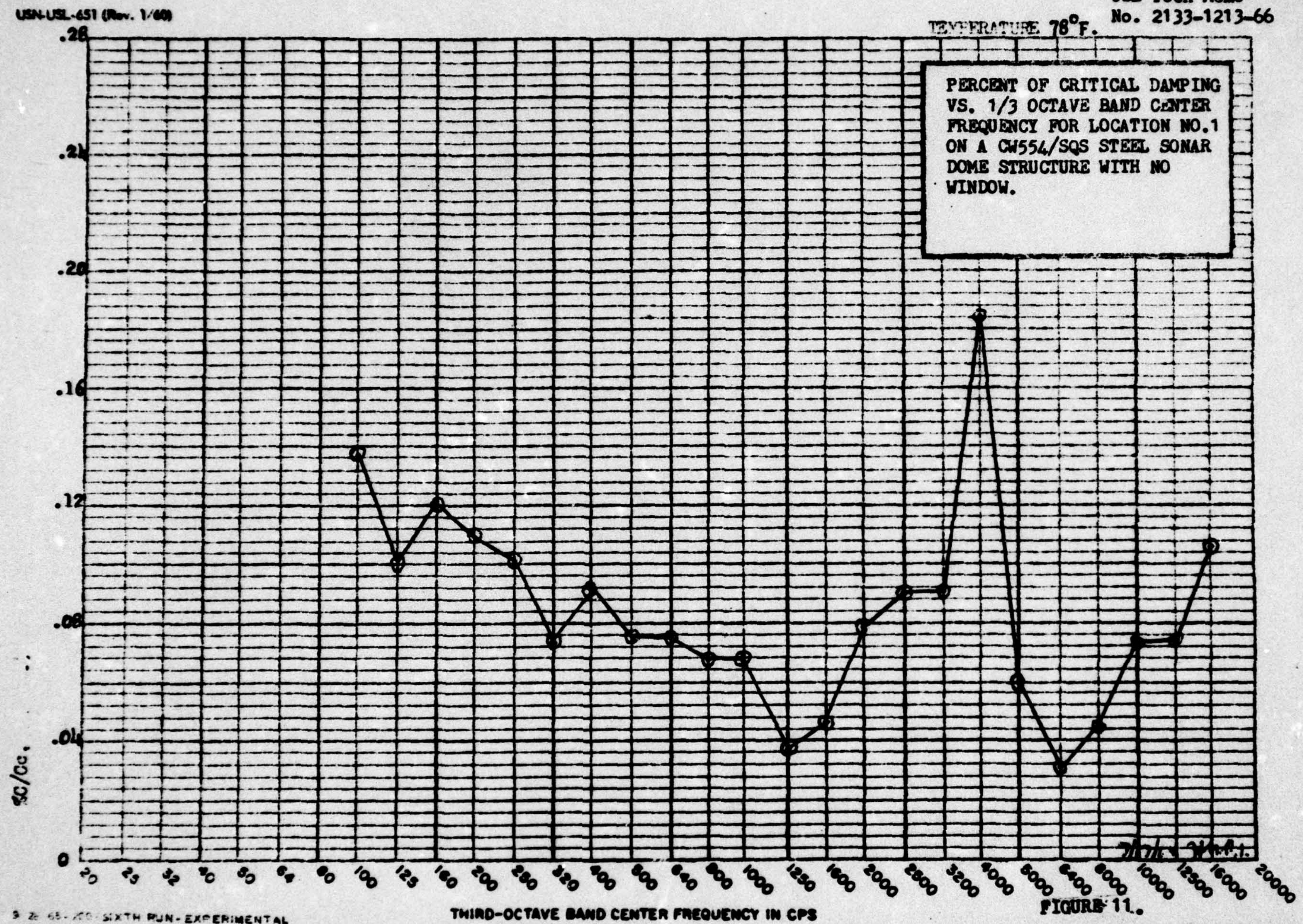

USN-USL-651 (Rev. 1/60)
TEMPERATURE 78°F.
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO.1 ON A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW.
.28
.24
.20
.16
.12
.08
.04
0
C/Cc.
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
SIXTH RUN - EXPERIMENTAL

FIGURE 11.

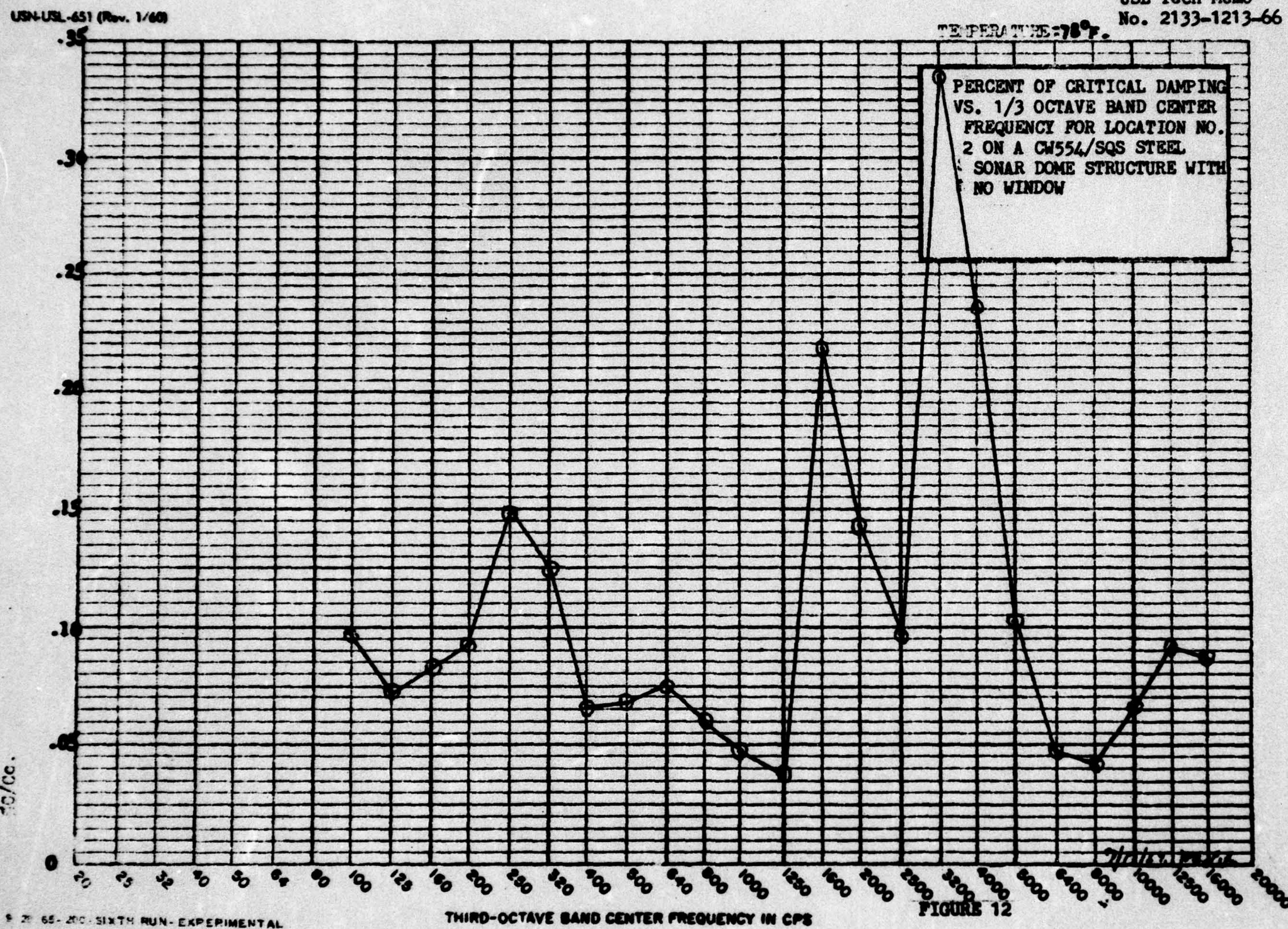
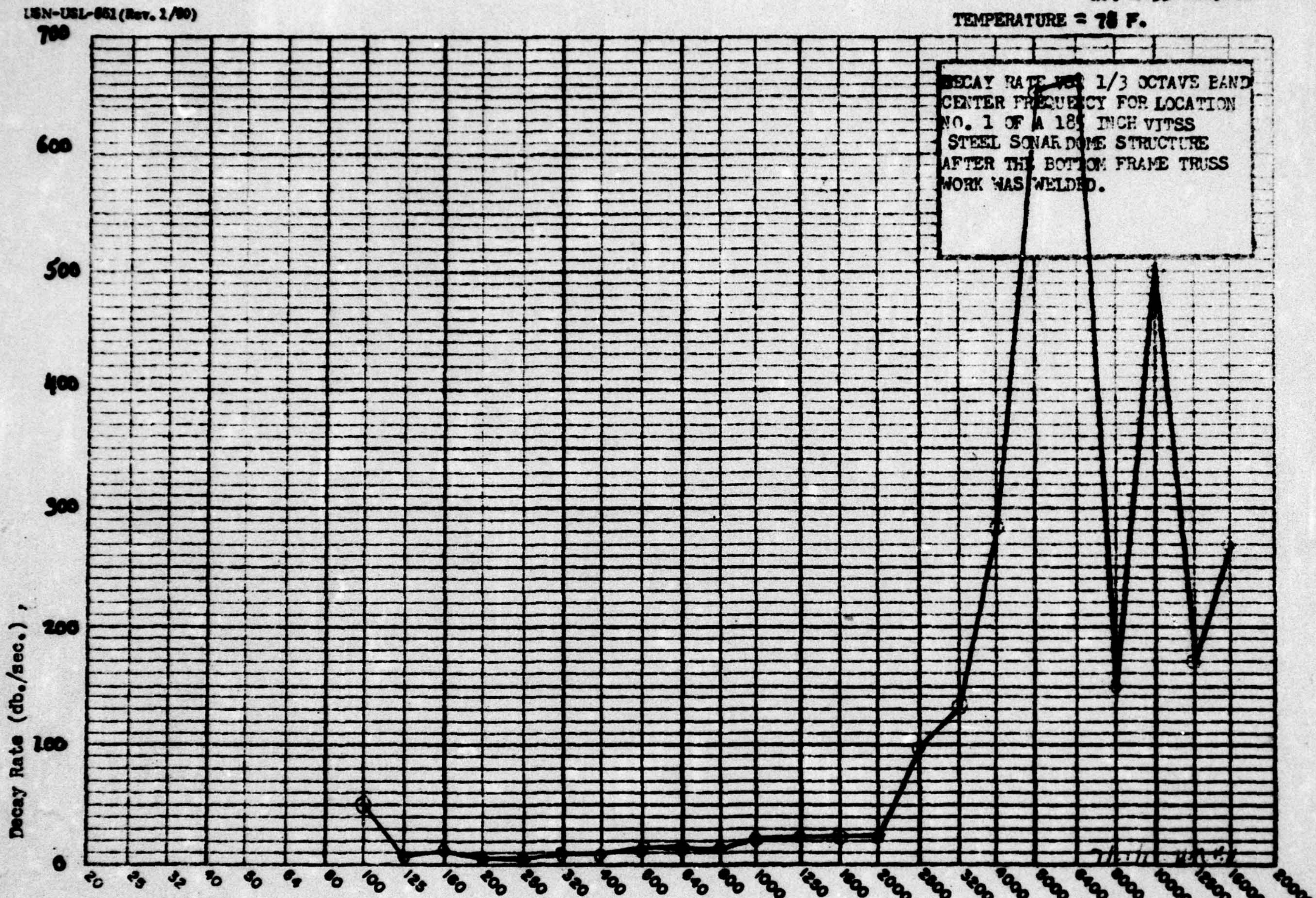

USN-USL-651 (Rev. 1/60)
TEMPERATURE: 78°F.
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 ON A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW
.35
.30
.25
.20
.15
.10
.05
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
9 21 65 - 200 - SIXTH RUN - EXPERIMENTAL

FIGURE 12

TEMPERATURE = 78 F.



1/20/60 - 600 - FIRST RUN - Below Standardization

FIGURE 13

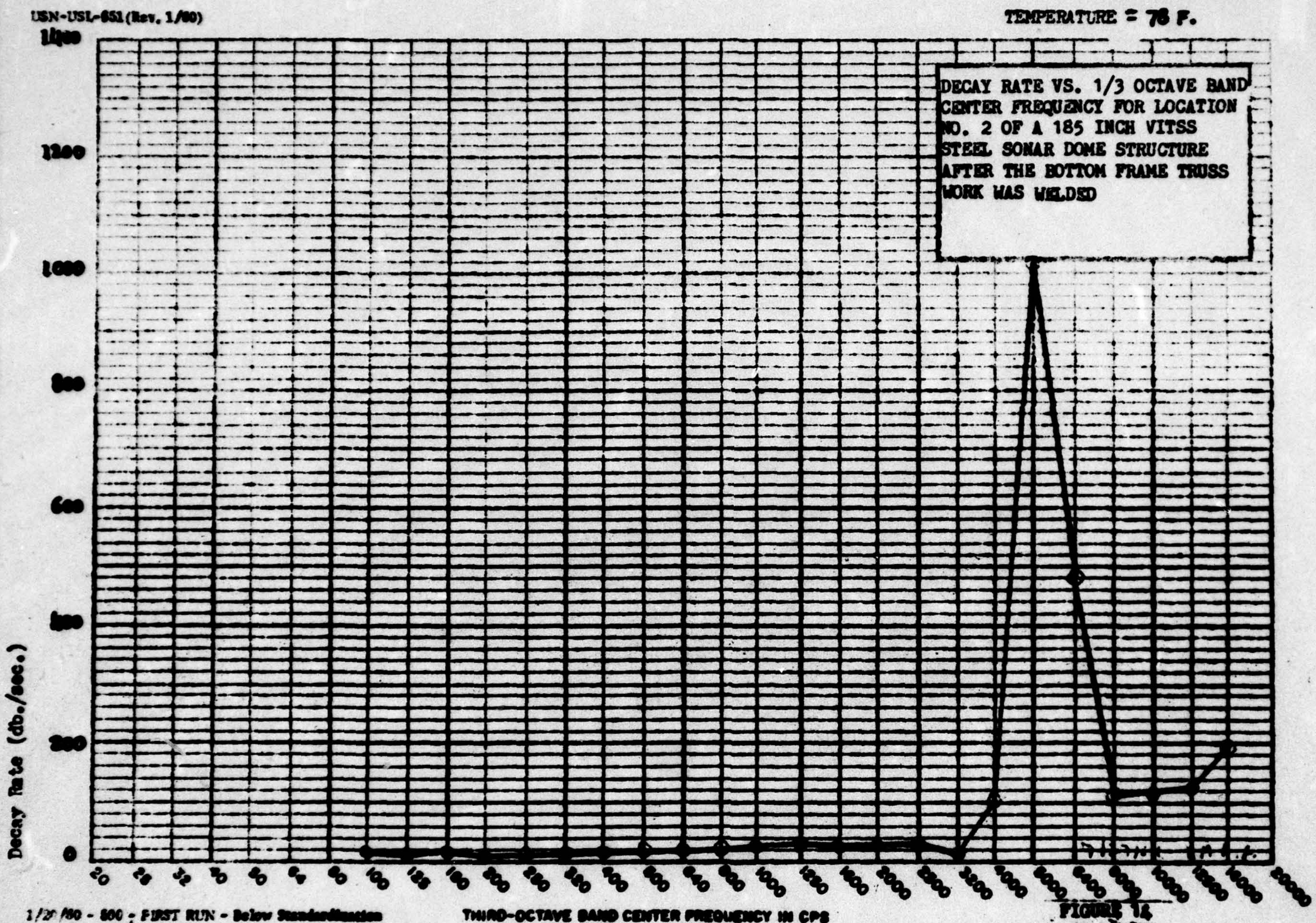

USN-USL-651(Rev. 1/60)
TEMPERATURE = 78 F.
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 OF A 185 INCH VITSS STEEL SONAR DOME STRUCTURE AFTER THE BOTTOM FRAME TRUSS WORK WAS WELDED
Decay Rate (db./sec.)
0
200
400
600
800
1000
1200
1400
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
1/2?/60 - 800 - FIRST RUN - Below Standardization

FIGURE 14

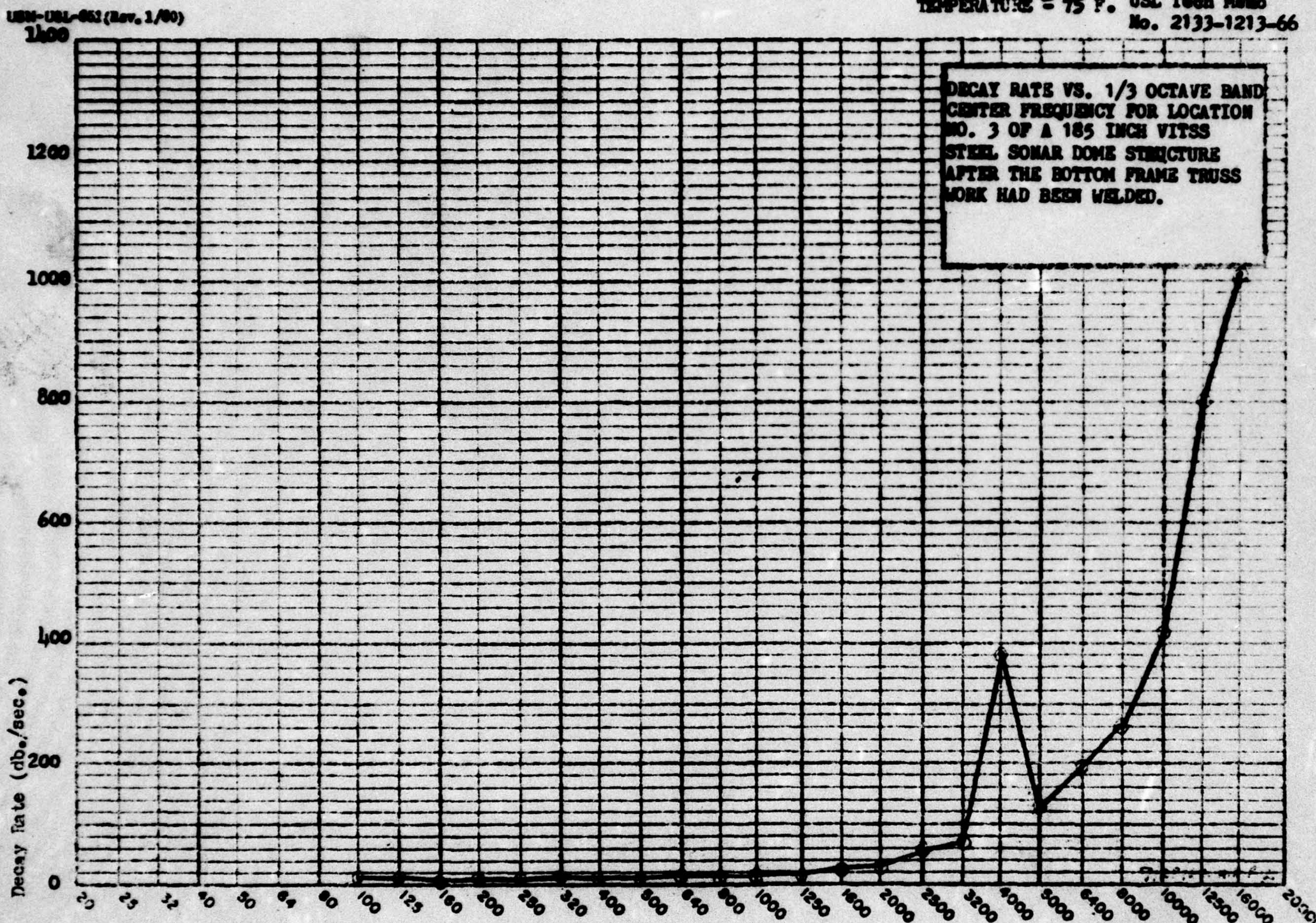

USN-USL-661(Rev. 1/60)
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 3 OF A 185 INCH VITSS STEEL SONAR DOME STRUCTURE AFTER THE BOTTOM FRAME TRUSS WORK HAD BEEN WELDED.
Decay Rate (db./sec.)
1400
1200
1000
800
600
400
200
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
500 - FIRST RUN - Below Standardization

FIGURE 15

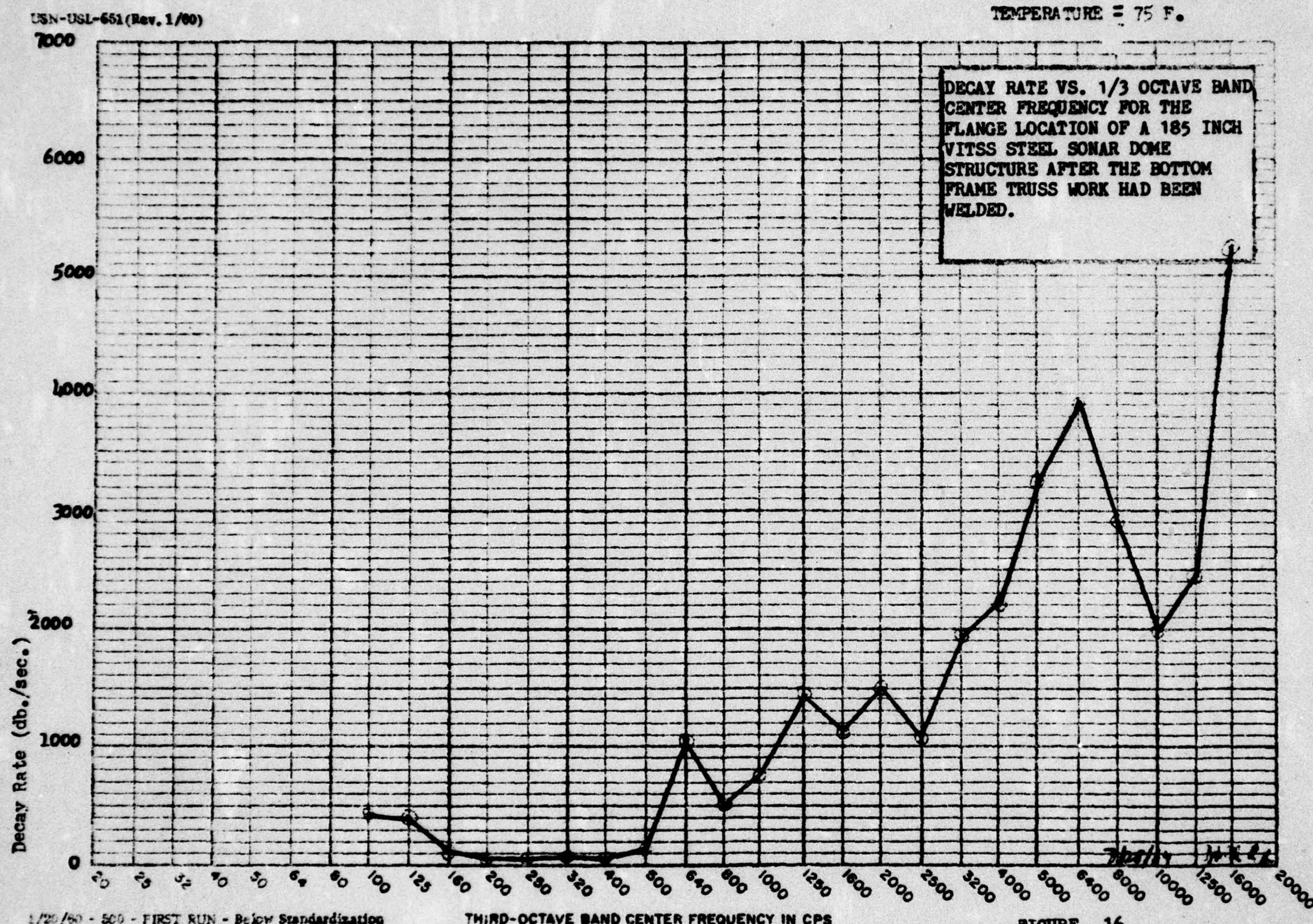

USN-USL-651(Rev. 1/60)
TEMPERATURE = 75 F.
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR THE FLANGE LOCATION OF A 185 INCH VITSS STEEL SONAR DOME STRUCTURE AFTER THE BOTTOM FRAME TRUSS WORK HAD BEEN WELDED.
Decay Rate (db./sec.)
7000
6000
5000
4000
3000
2000
1000
0
20 25 32 40 50 64 80 100 125 160 200 250 320 400 500 640 800 1000 1250 1600 2000 2500 3200 4000 5000 6400 8000 10000 12500 16000 20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
1/20/60 - 500 - FIRST RUN - Below Standardization

FIGURE 16

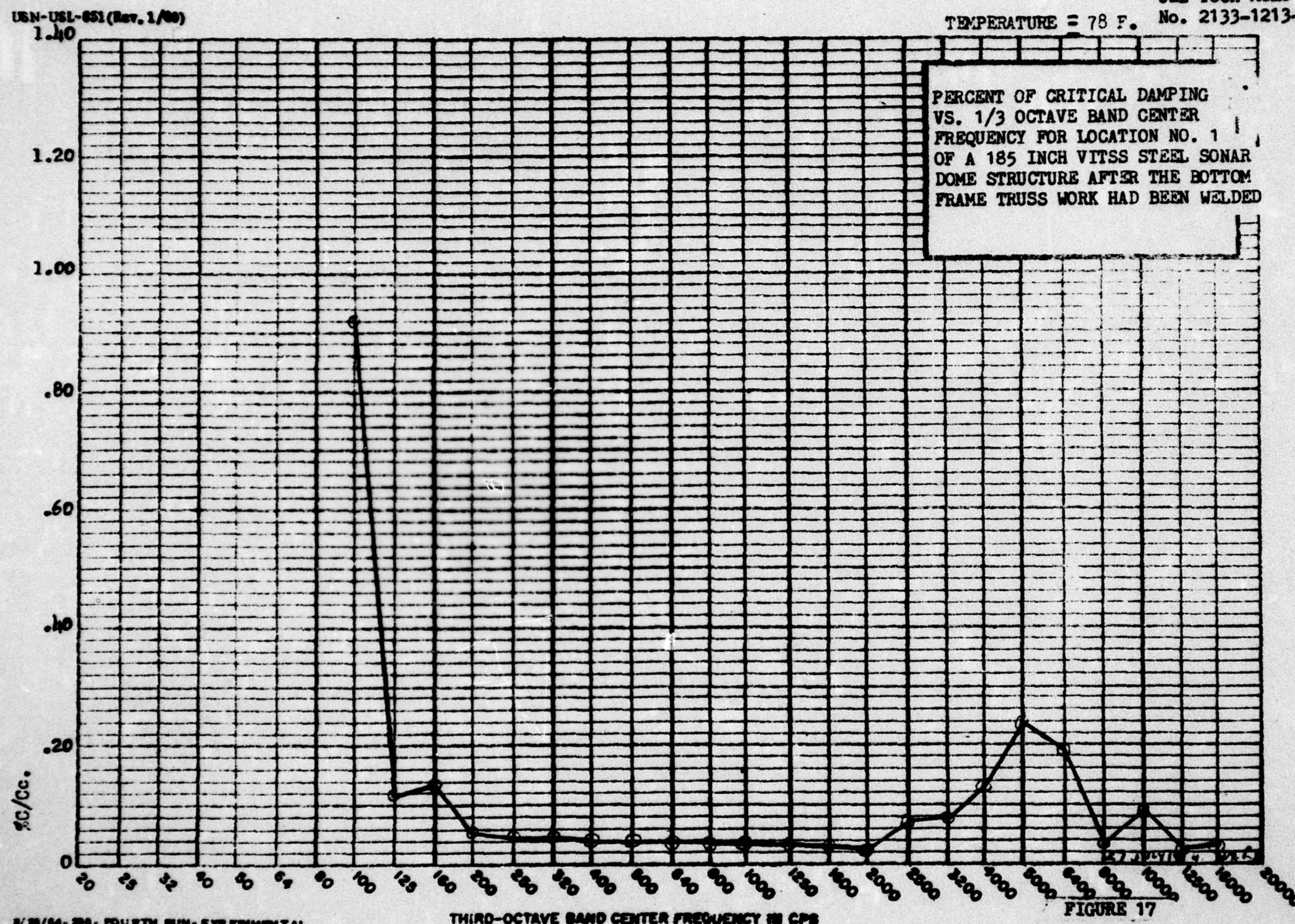
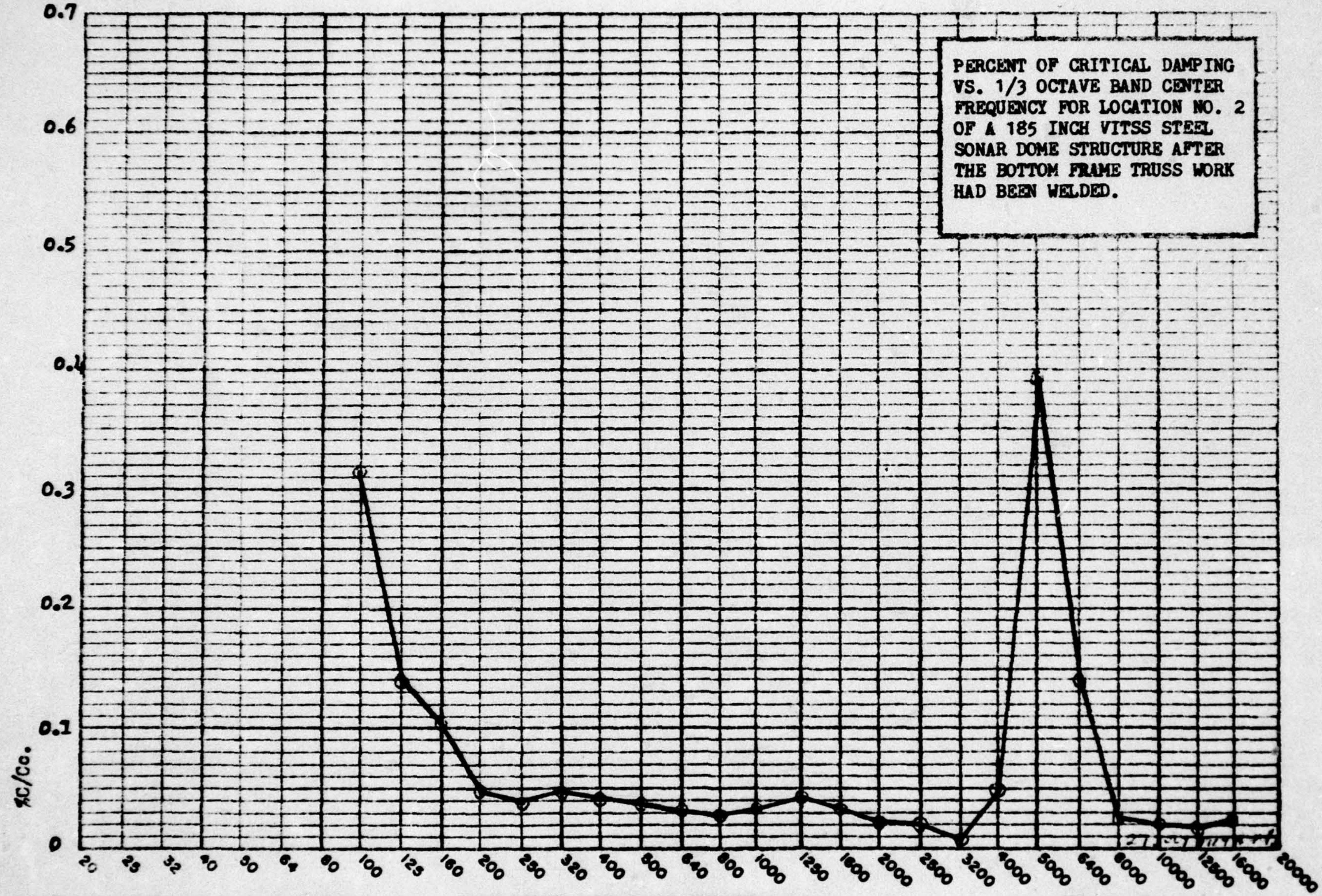

USN-USL-851(Rev.1/60)
TEMPERATURE = 78 F.
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 1 OF A 185 INCH VITSS STEEL SONAR DOME STRUCTURE AFTER THE BOTTOM FRAME TRUSS WORK HAD BEEN WELDED
%C/Cc.
1.40
1.20
1.00
.80
.60
.40
.20
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
3/30/64-206- FOURTH RUN-EXPERIMENTAL

FIGURE 17

TEMPERATURE = 78 F.

USN-USL-651 (Rev. 1/60)



1/20/60 - 500 - FIRST RUN - Below Standardization

FIGURE 18

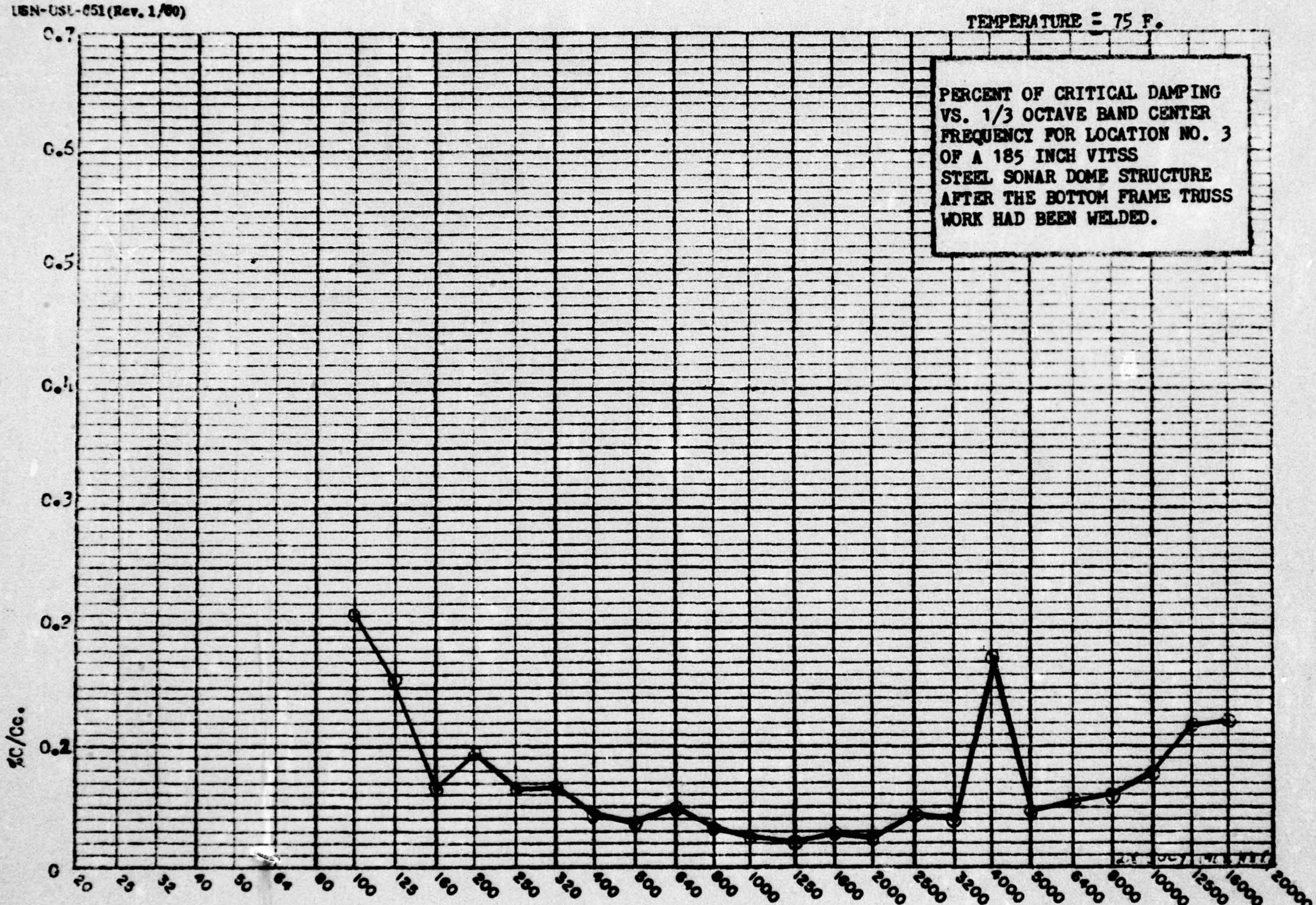
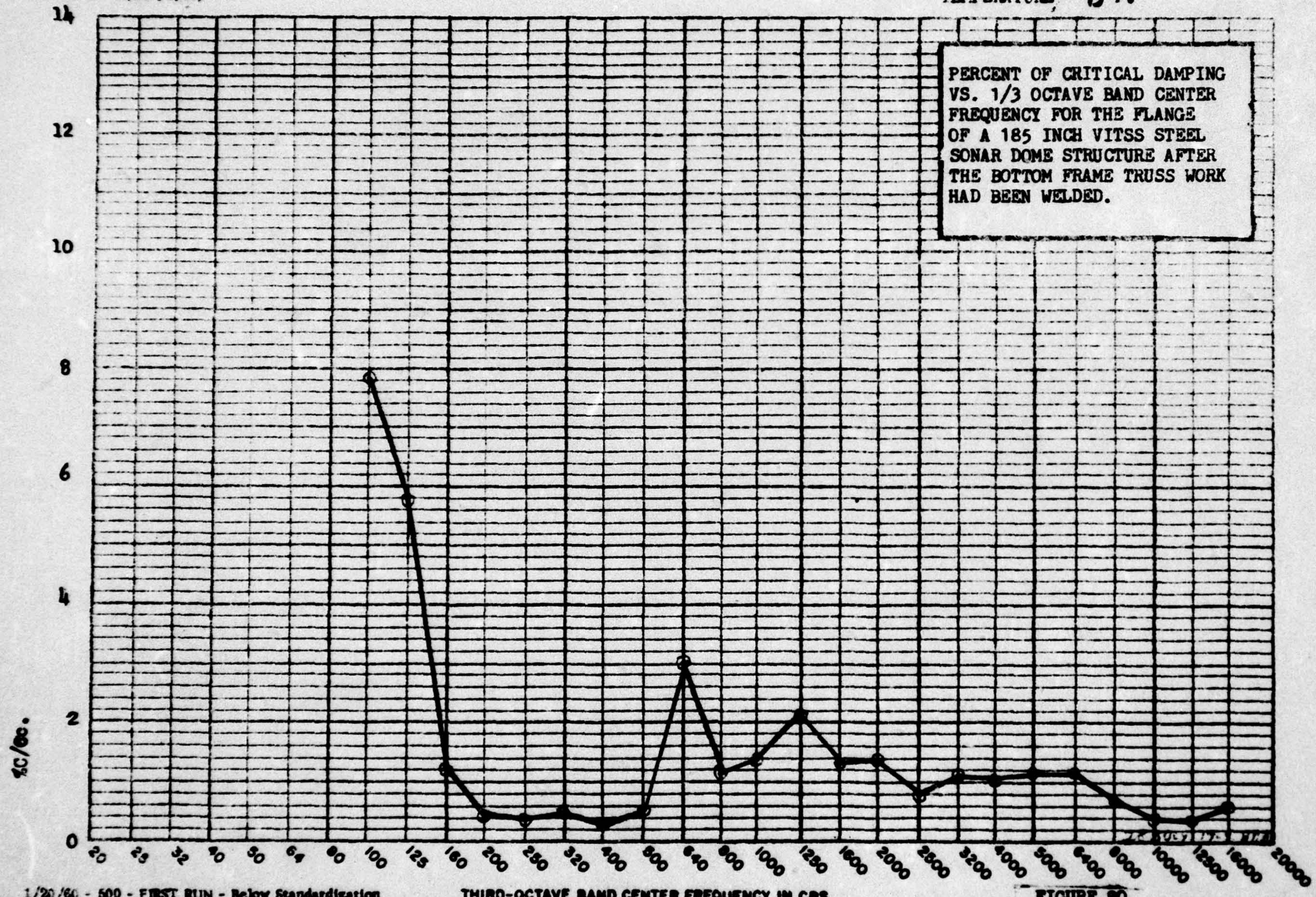

USN-USL-651(Rev. 1/60)
TEMPERATURE = 75 F.
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 3 OF A 185 INCH VITSS STEEL SONAR DOME STRUCTURE AFTER THE BOTTOM FRAME TRUSS WORK HAD BEEN WELDED.
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
%C/Cc.
20 25 32 40 50 64 80 100 125 160 200 250 320 400 500 640 800 1000 1250 1600 2000 2500 3200 4000 5000 6400 8000 10000 12500 16000 20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
1/20/60 - 500 - FIRST RUN - below Standardization

FIGURE 19

USN-USL-651(Rev. 1/60)

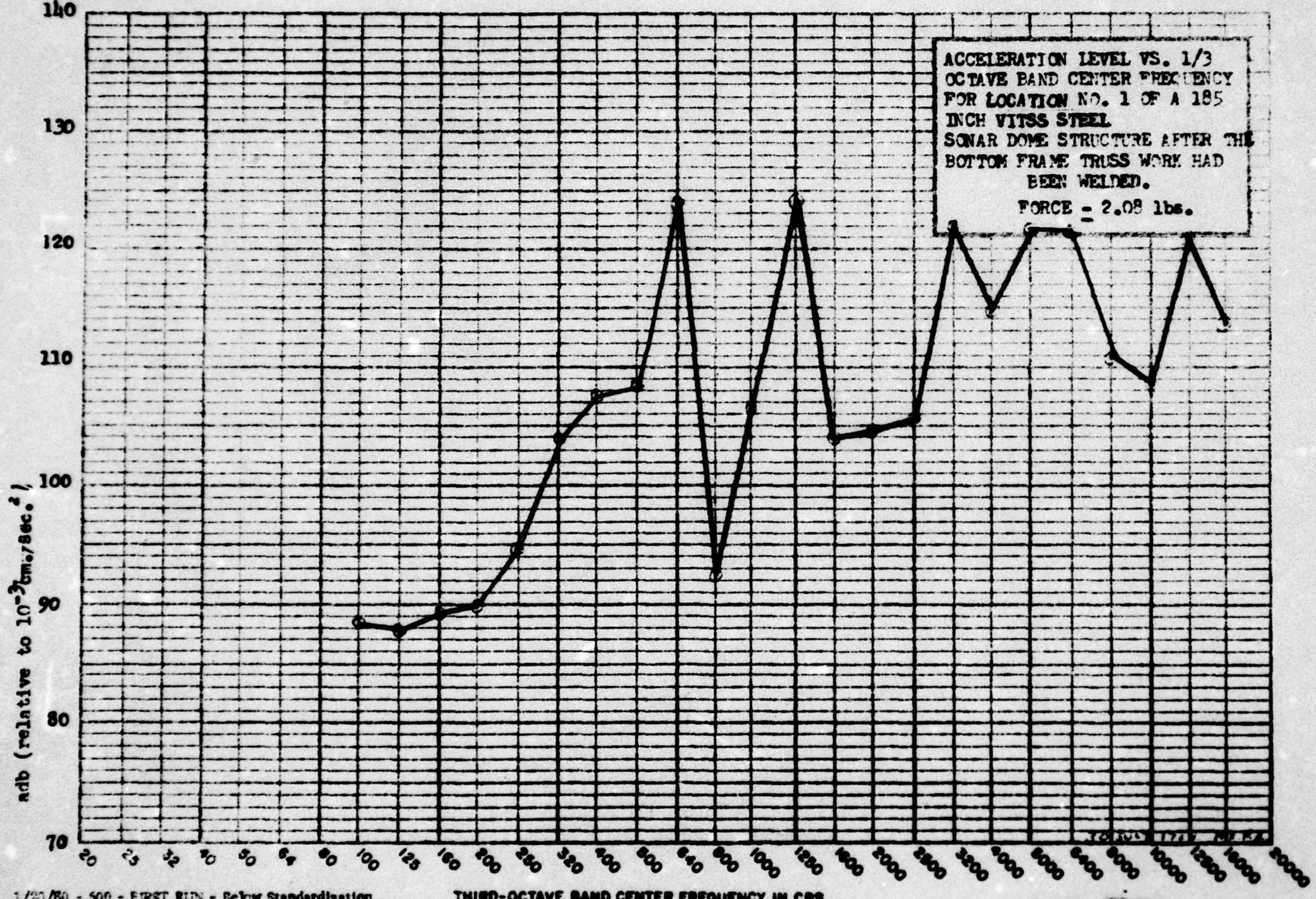
TEMPERATURE = 75 F.



1/20/60 - 500 - FIRST RUN - Below Standardization

FIGURE 20

TEMPERATURE = 79 F.



1/20/60 - 500 - FIRST RUN - Below Standardization

FIGURE 21

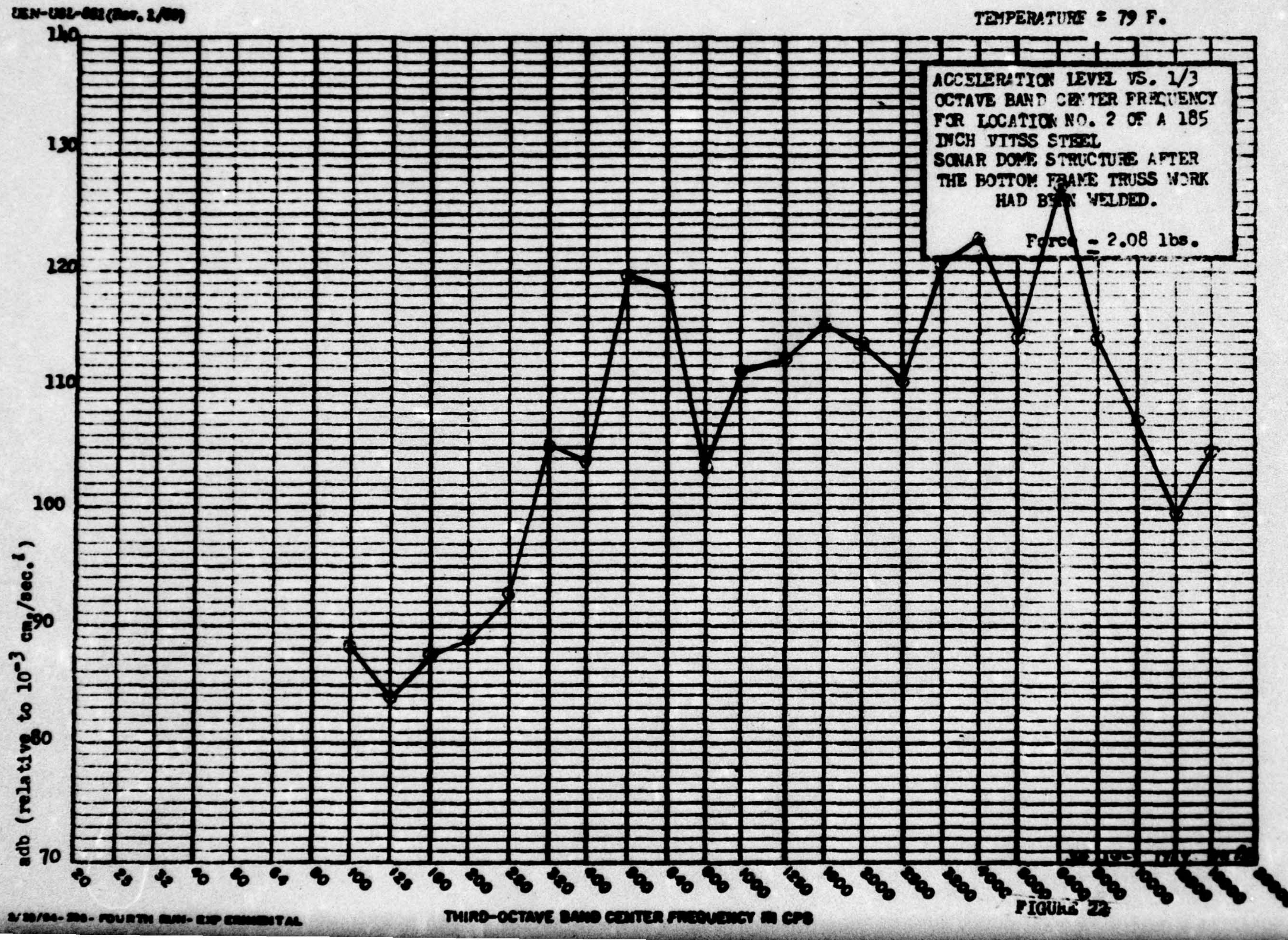
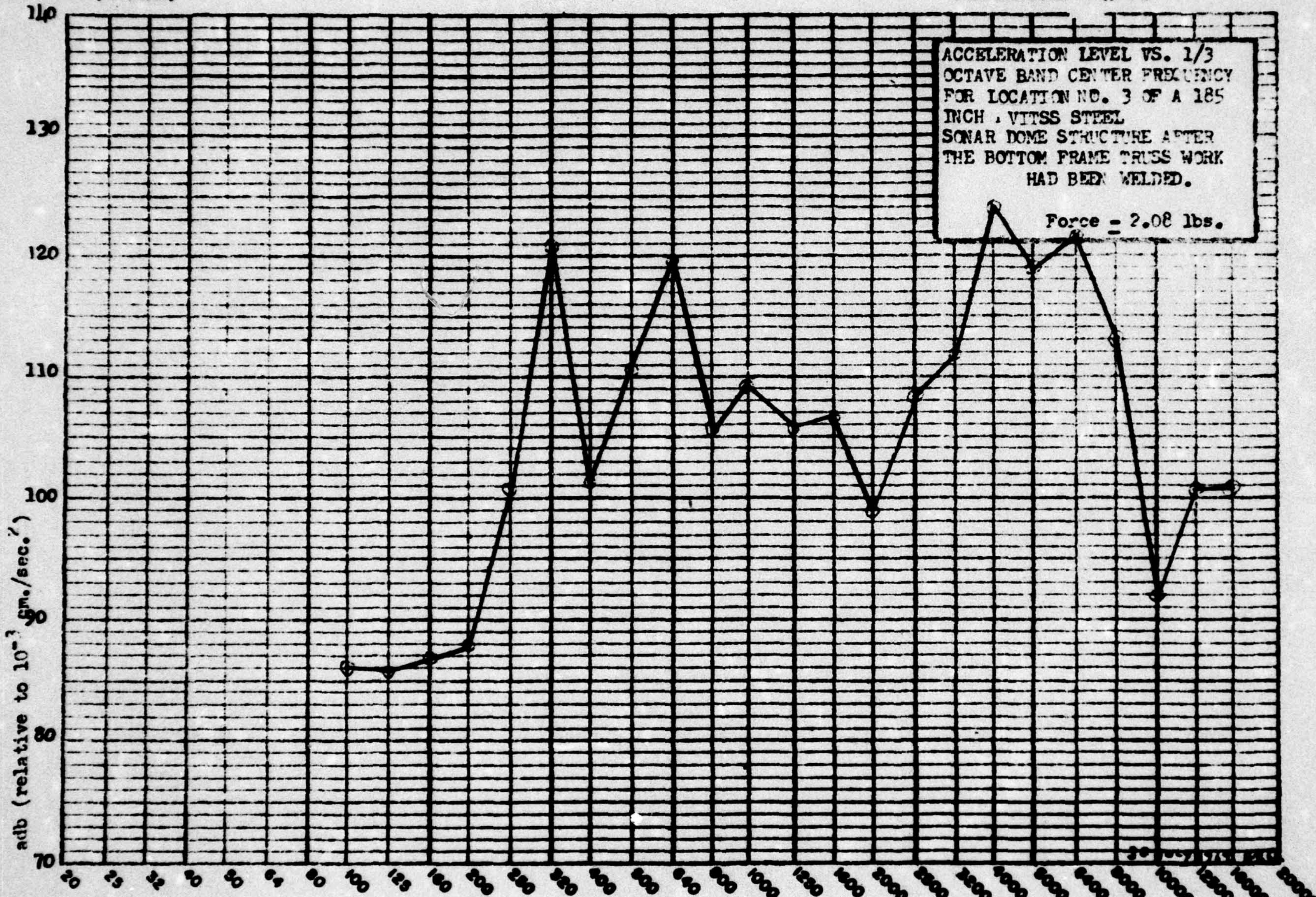

TEMPERATURE = 79 F.
ACCELERATION LEVEL VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 OF A 185 INCH VITSS STEEL SONAR DOME STRUCTURE AFTER THE BOTTOM FRAME TRUSS WORK HAD BEEN WELDED.
Force = 2.08 lbs.
140
130
120
110
100
90
80
70
adb (relative to 10^{-3} $cm_s/sec.^2$)
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS

FIGURE 22

USN-USL-851(Rev. 1/60)

TEMPERATURE = 79 F.



3/30/64- 250- FOURTH RUN- EXPERIMENTAL

FIGURE 23

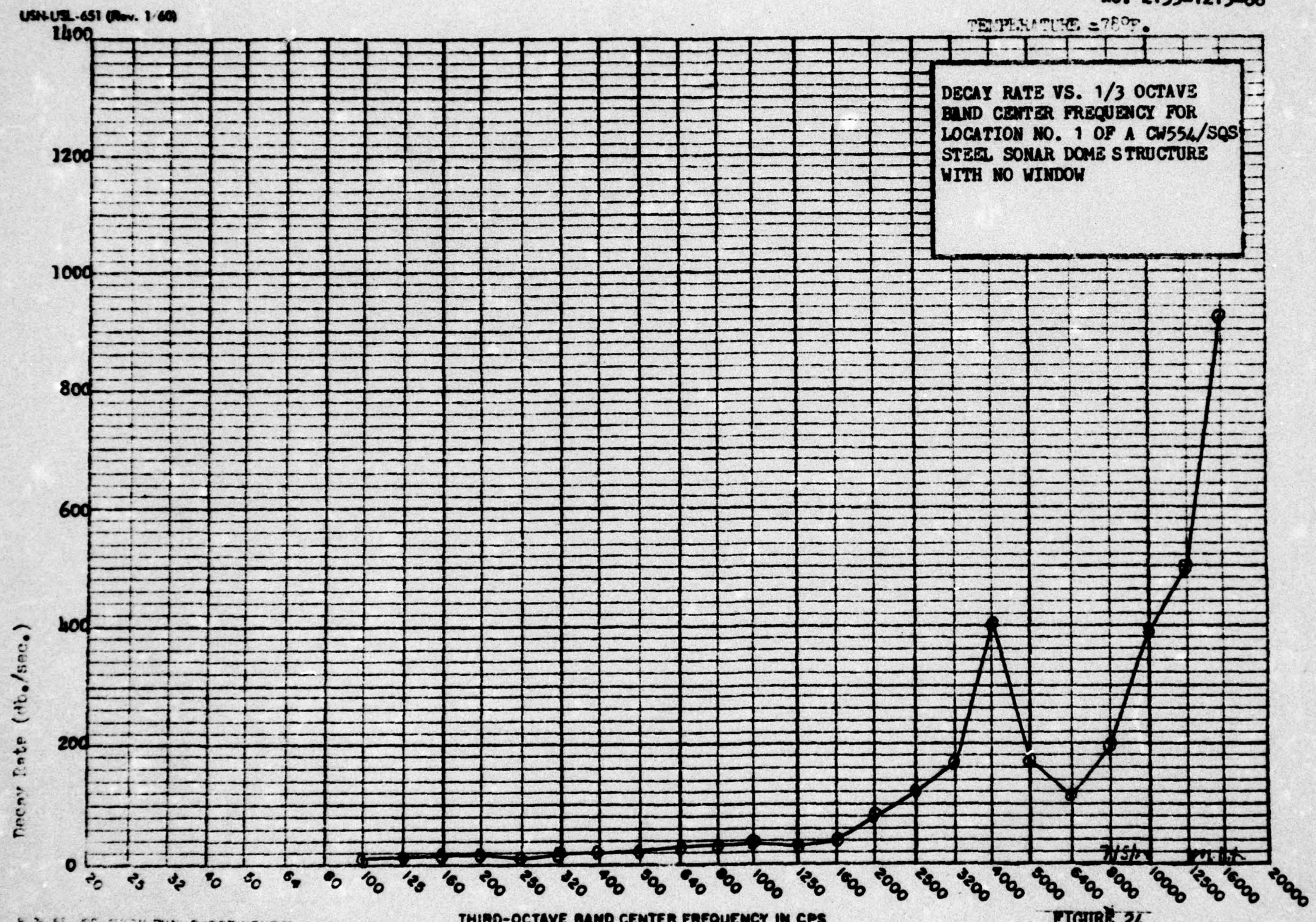

USN-USL-651 (Rev. 1/60)
TEMPERATURE =78°F.
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 1 OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW
Decay Rate (db./sec.)
0
200
400
600
800
1000
1200
1400
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS

FIGURE 24

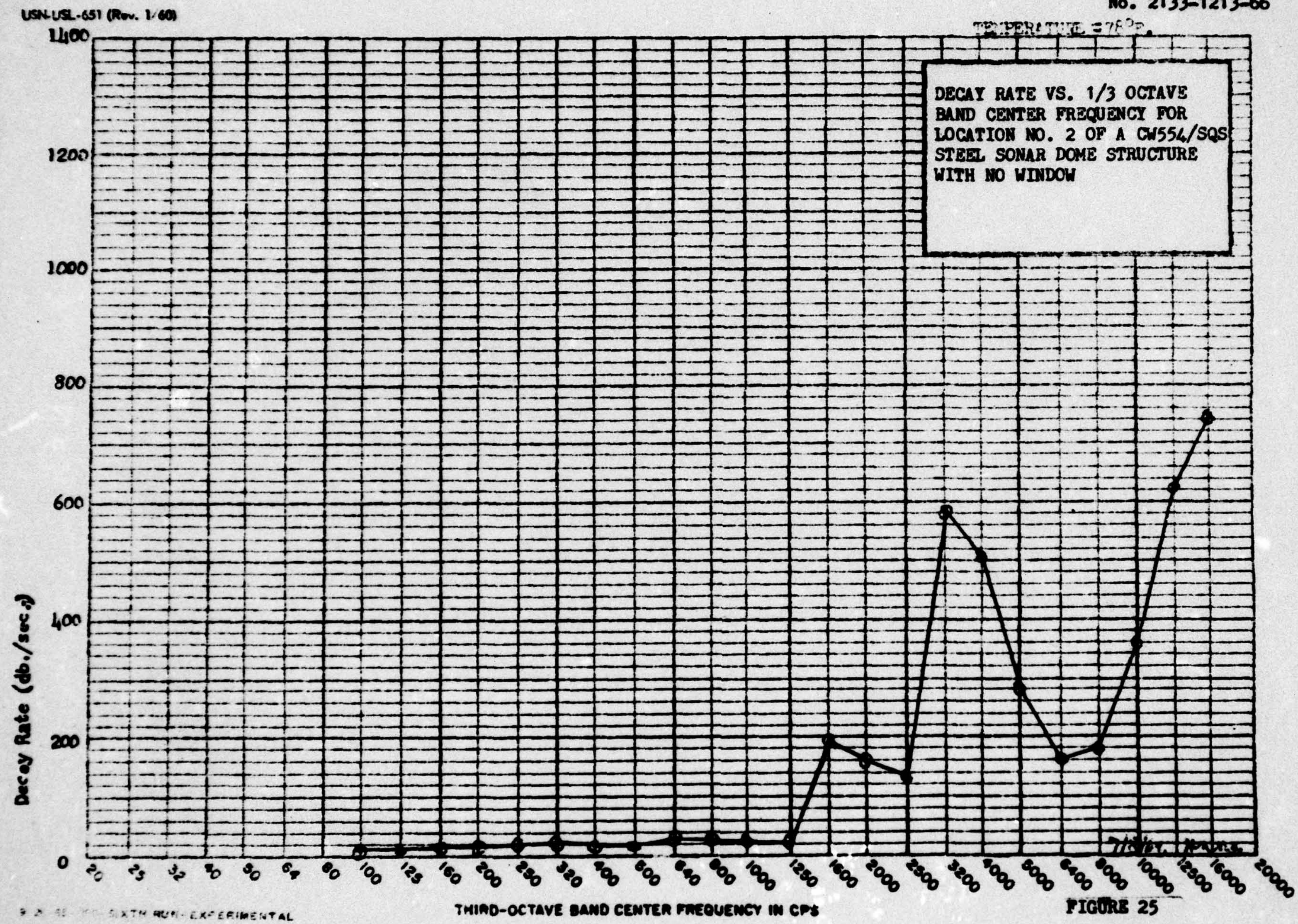

USN-USL-651 (Rev. 1/60)
TEMPERATURE = 78°F.
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW
Decay Rate (db./sec.)
0
200
400
600
800
1000
1200
1400
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
SIXTH RUN-EXPERIMENTAL

FIGURE 25

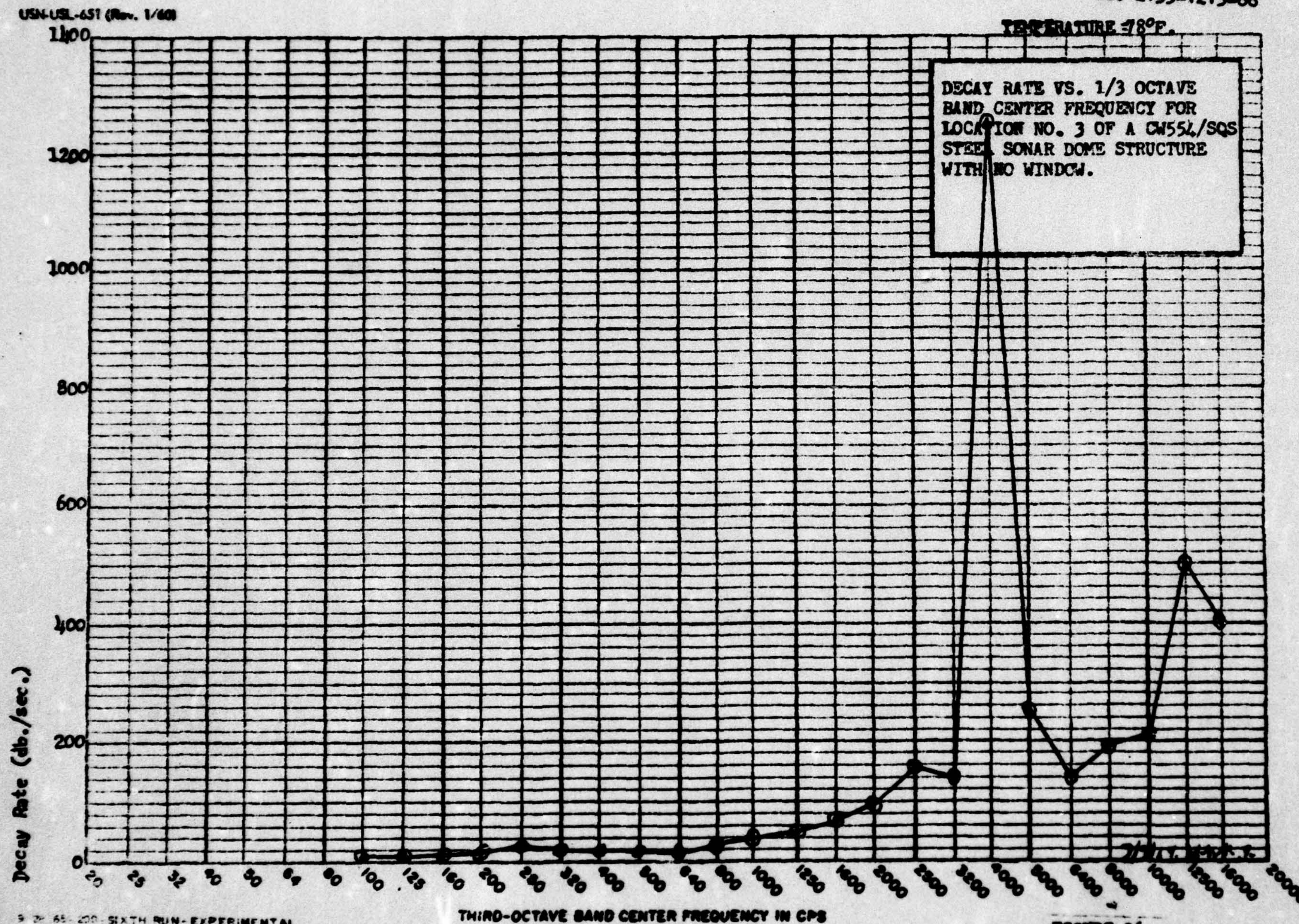

USN-USL-651 (Rev. 1/60)
TEMPERATURE 78°F.
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 3 OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW.
Decay Rate (db./sec.)
1400
1200
1000
800
600
400
200
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
9-21-65-200-SIXTH RUN-EXPERIMENTAL

FIGURE 26

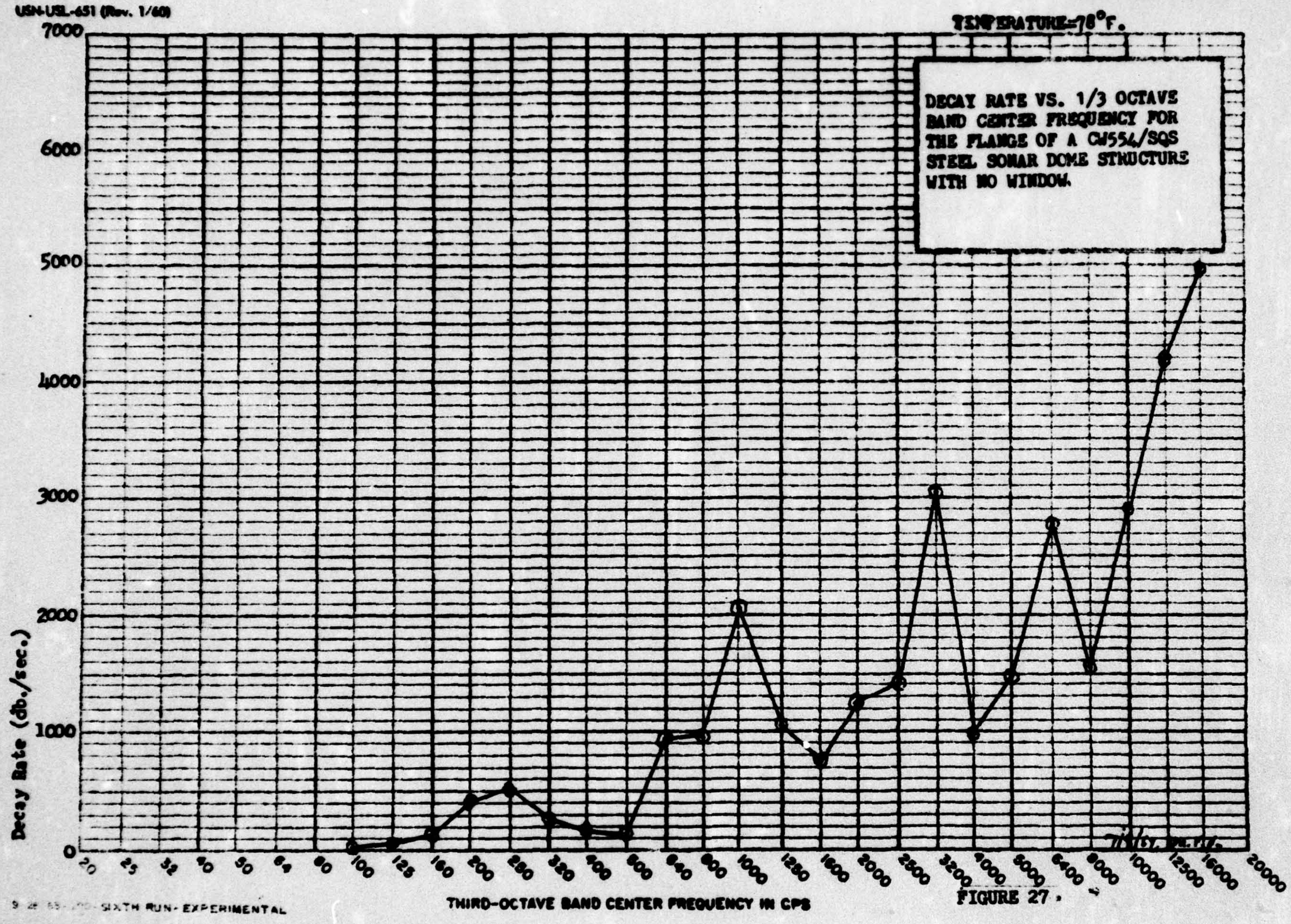
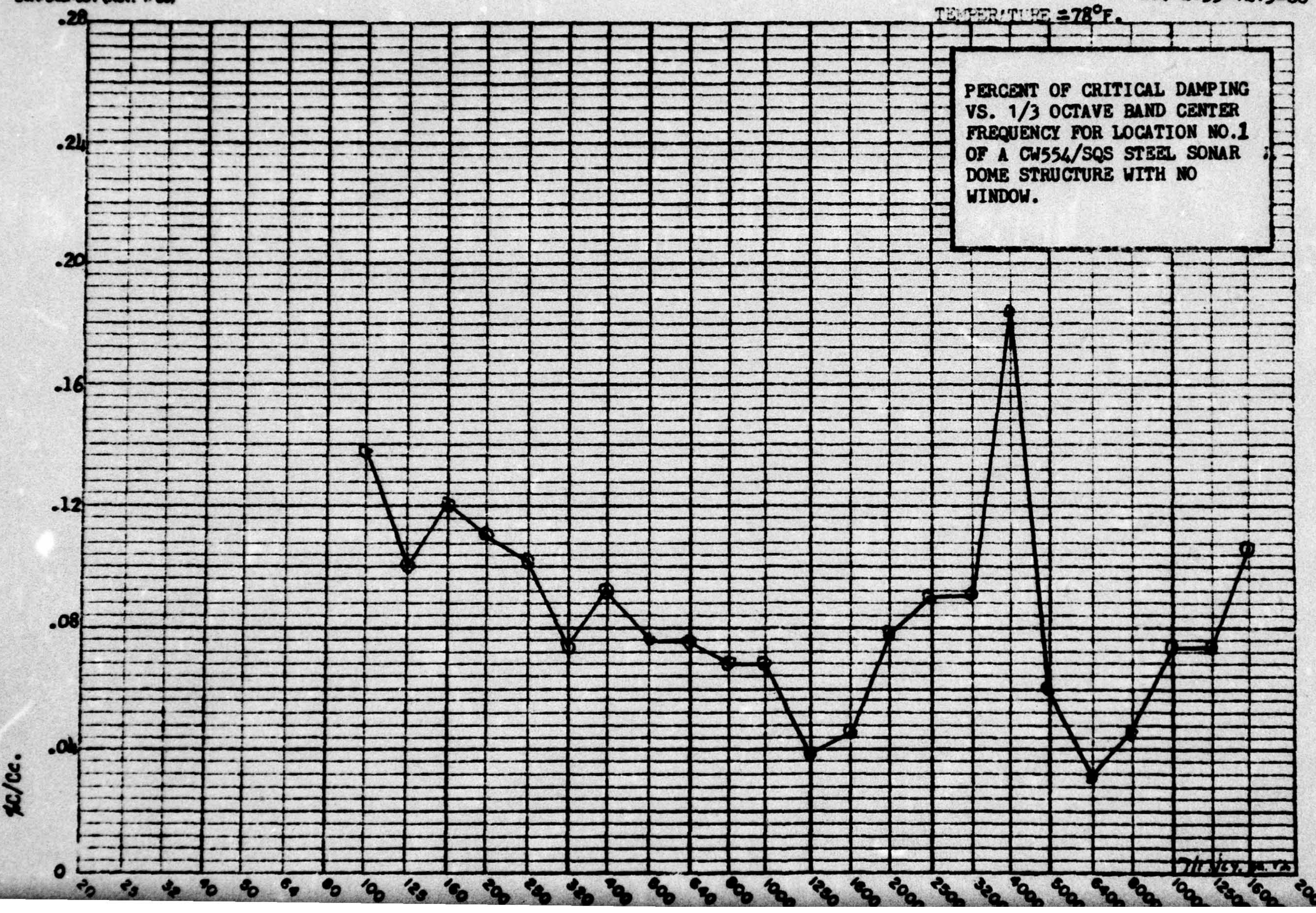
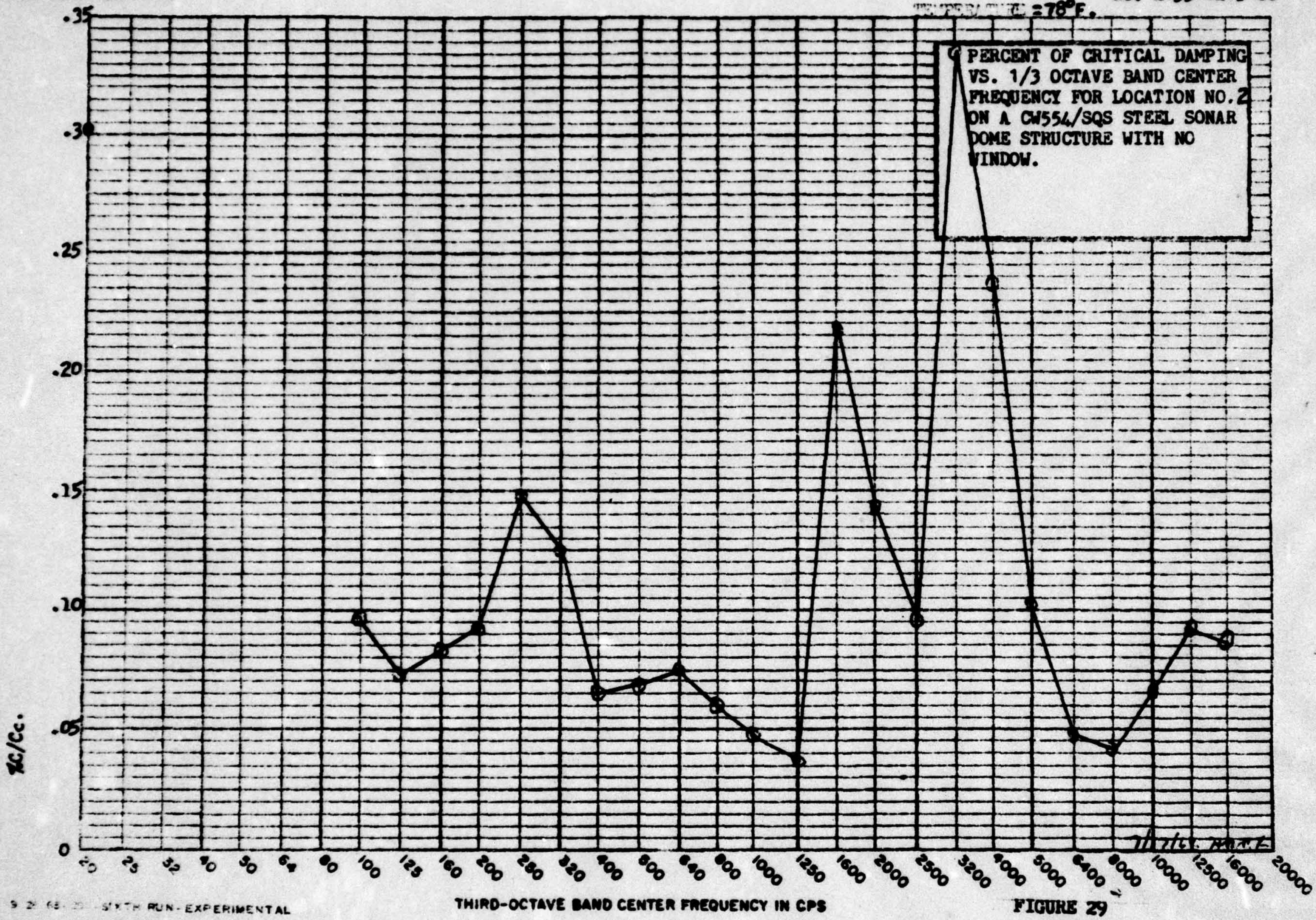

USN-USL-651 (Rev. 1/60)
TEMPERATURE=78°F.
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR THE FLANGE OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW.
Decay Rate (db./sec.)
0
1000
2000
3000
4000
5000
6000
7000
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
SIXTH RUN - EXPERIMENTAL

FIGURE 27.


USN-USL-651 (Rev. 1/60)
TEMPERATURE = 78°F.
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO.1 OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW.
%C/Cc.
.28
.24
.20
.16
.12
.08
.04
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000

USN-USL-651 (Rev. 1-60)



SIXTH RUN - EXPERIMENTAL

FIGURE 29

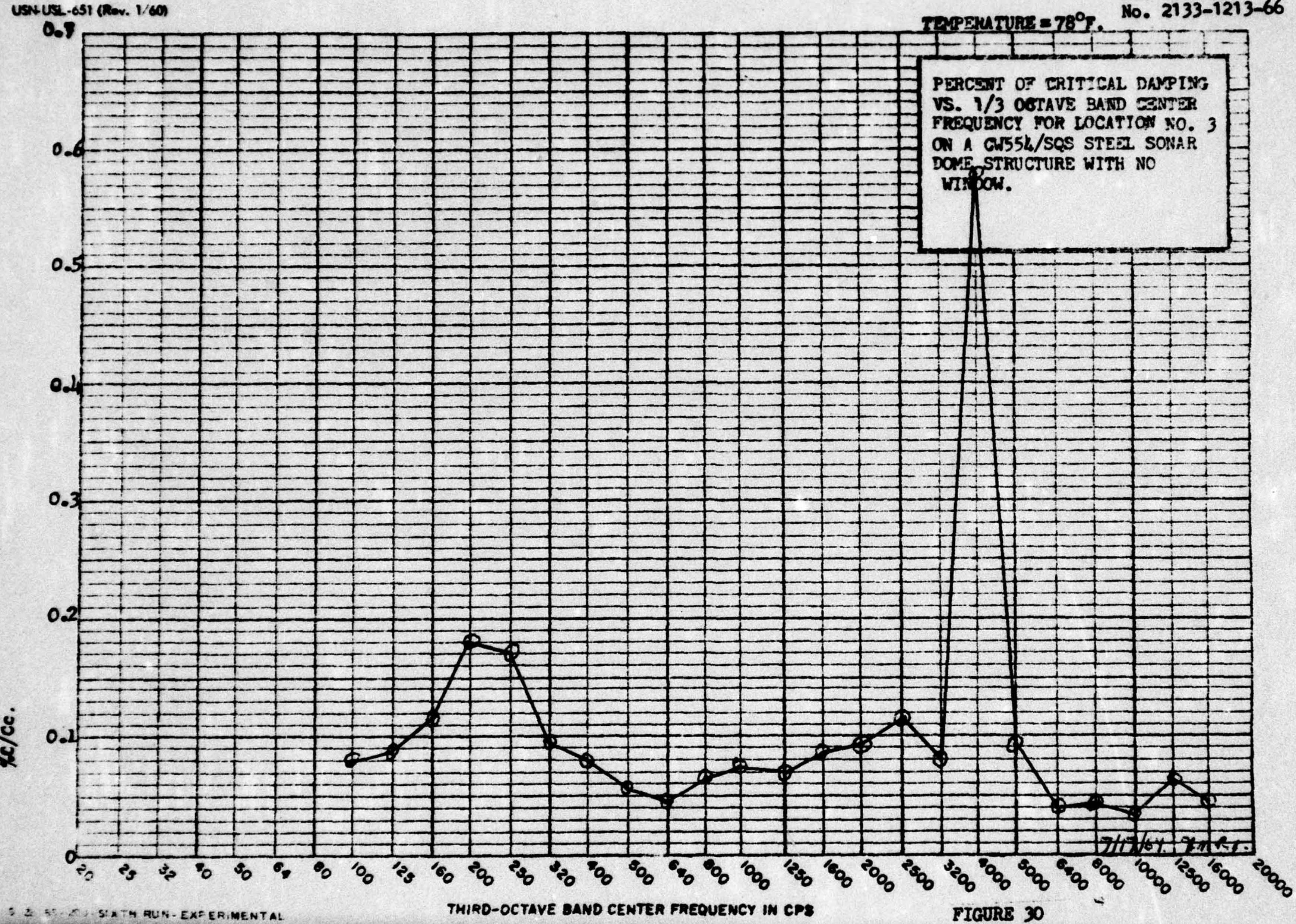

USN-USL-651 (Rev. 1/60)
TEMPERATURE = 78°F.
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 3 ON A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW.
%C/CC.
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
SIXTH RUN-EXPERIMENTAL

FIGURE 30

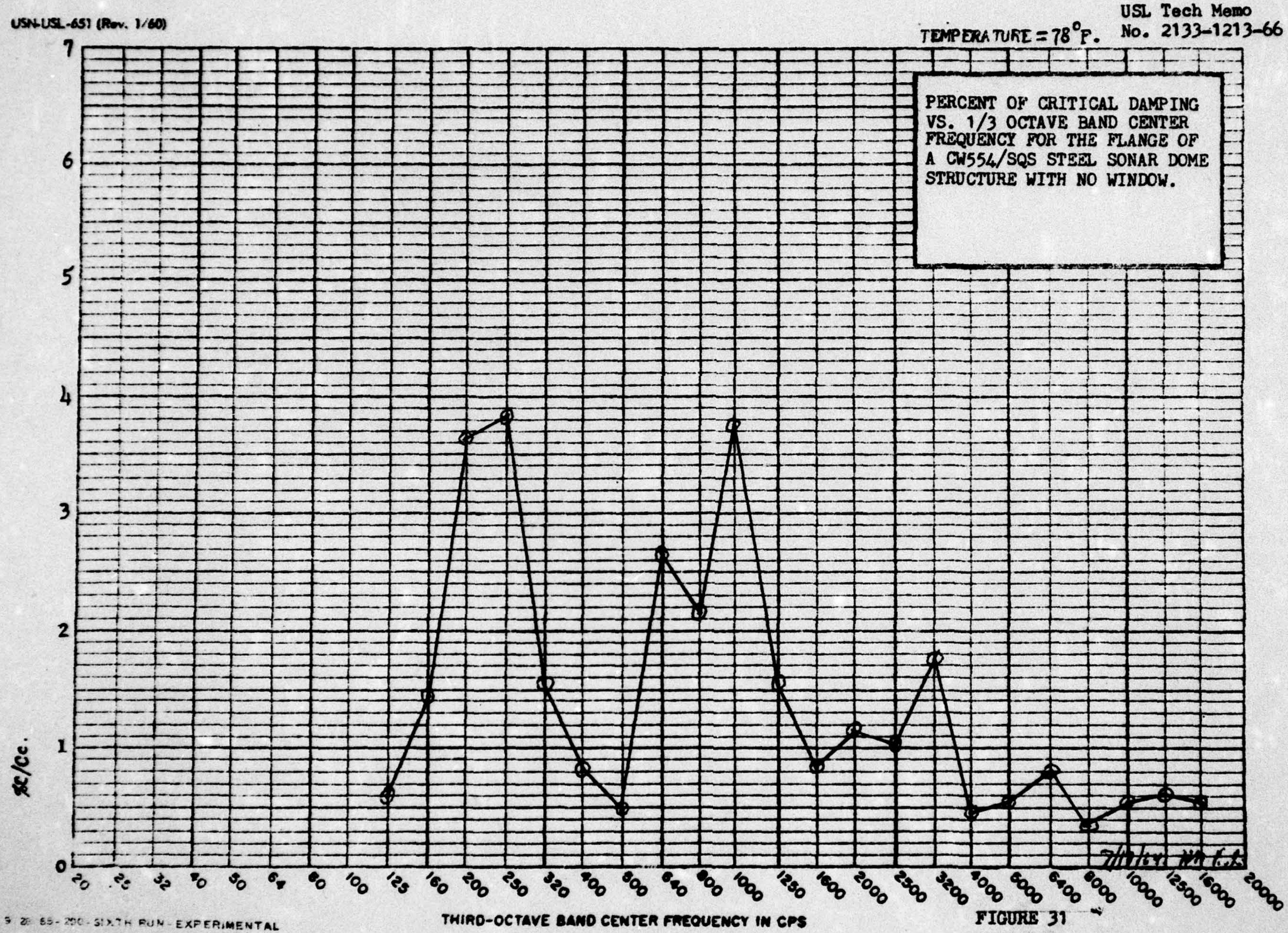

USN-USL-651 (Rev. 1/60)
TEMPERATURE = 78°F.
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR THE FLANGE OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW.
%C/Cc.
0
1
2
3
4
5
6
7
20 25 32 40 50 64 80 100 125 160 200 250 320 400 500 640 800 1000 1250 1600 2000 2500 3200 4000 5000 6400 8000 10000 12500 16000 20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
9-28-65-200-SIXTH RUN-EXPERIMENTAL

FIGURE 31

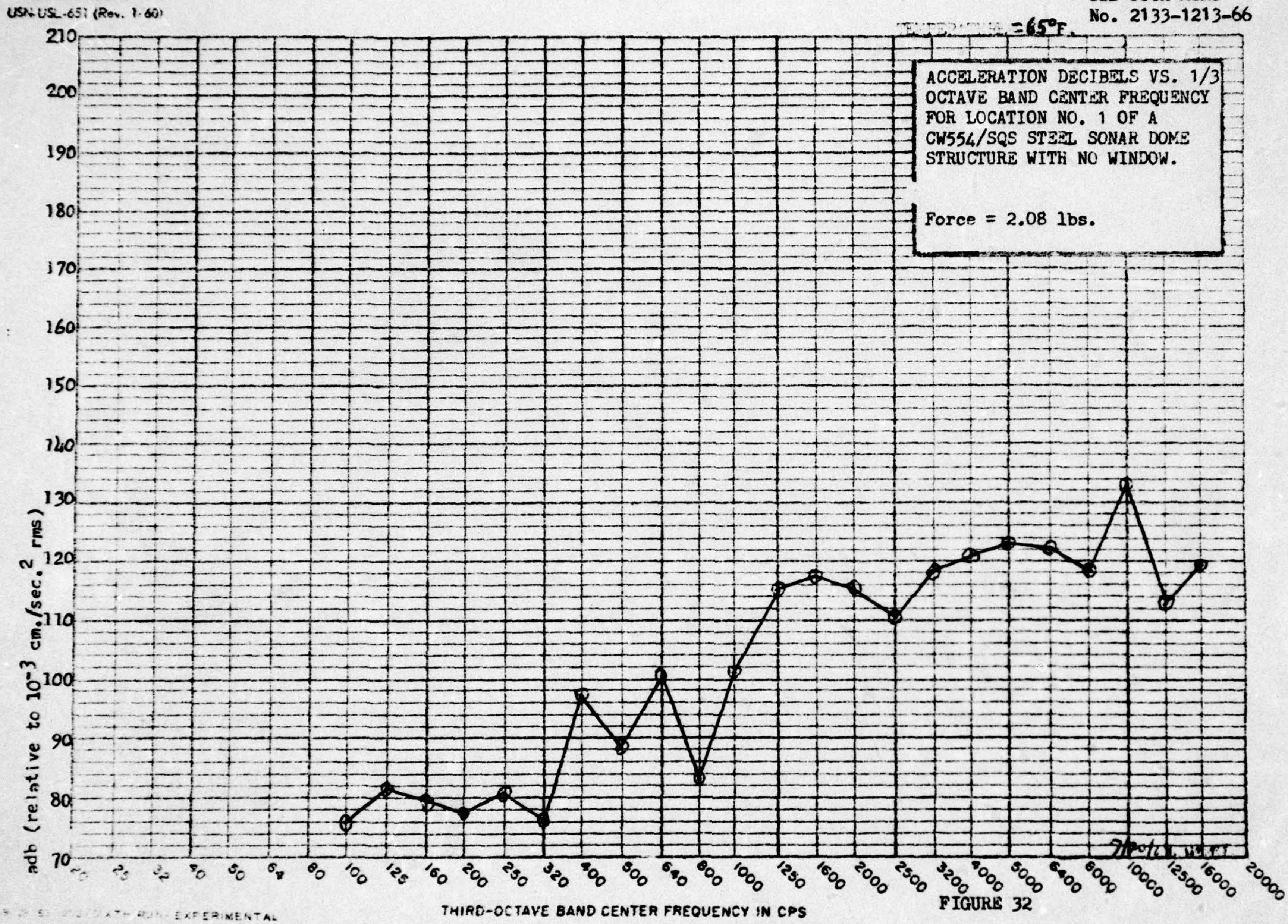

USN-USL-651 (Rev. 1-60)
=65°F.
ACCELERATION DECIBELS VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 1 OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW.
Force = 2.08 lbs.
adb (relative to 10^{-3} cm./sec.^{2} rms)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
EXPERIMENTAL

FIGURE 32

USL Tech Memo
No. 2133-1213-66

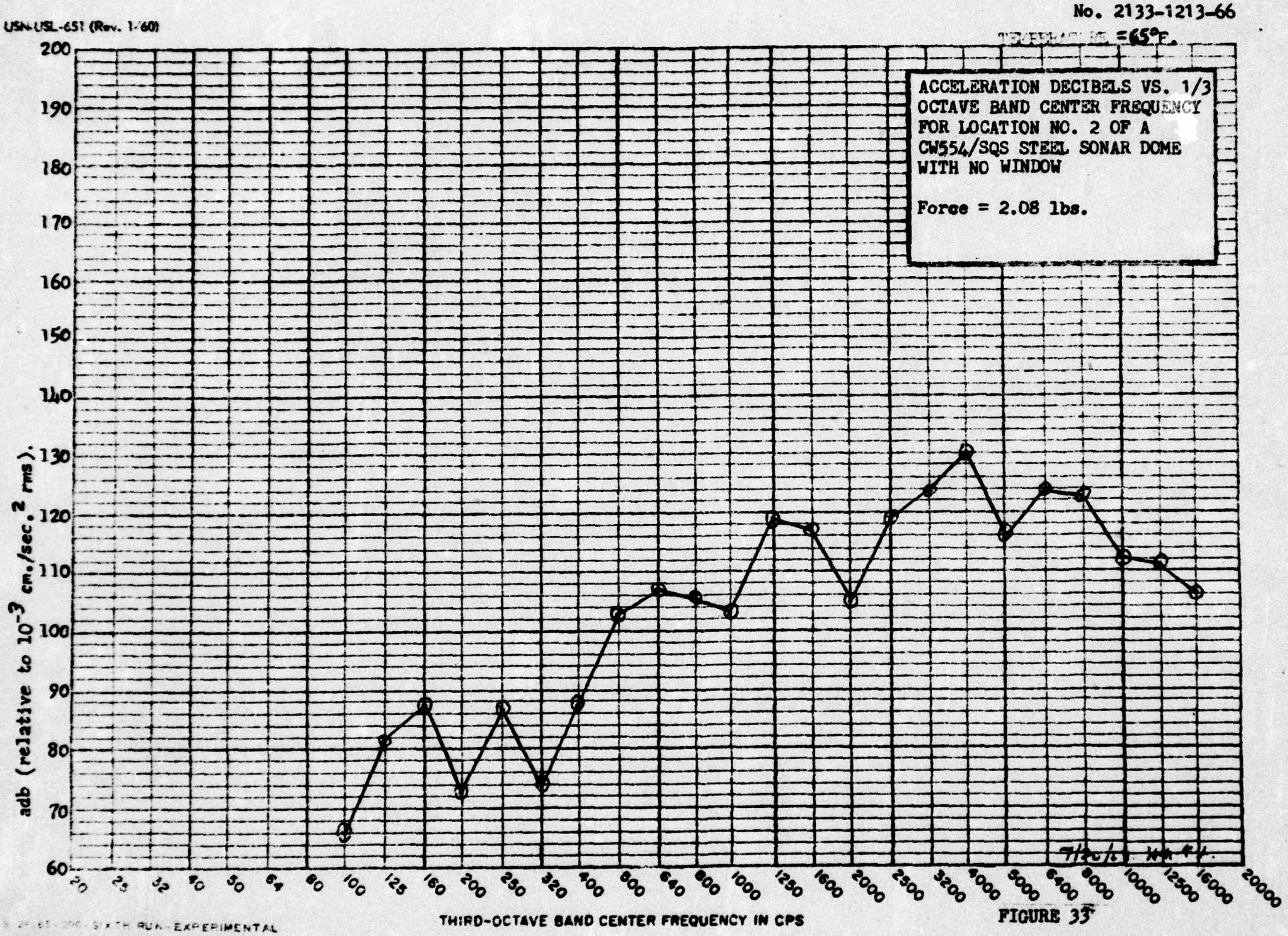


FIGURE 33

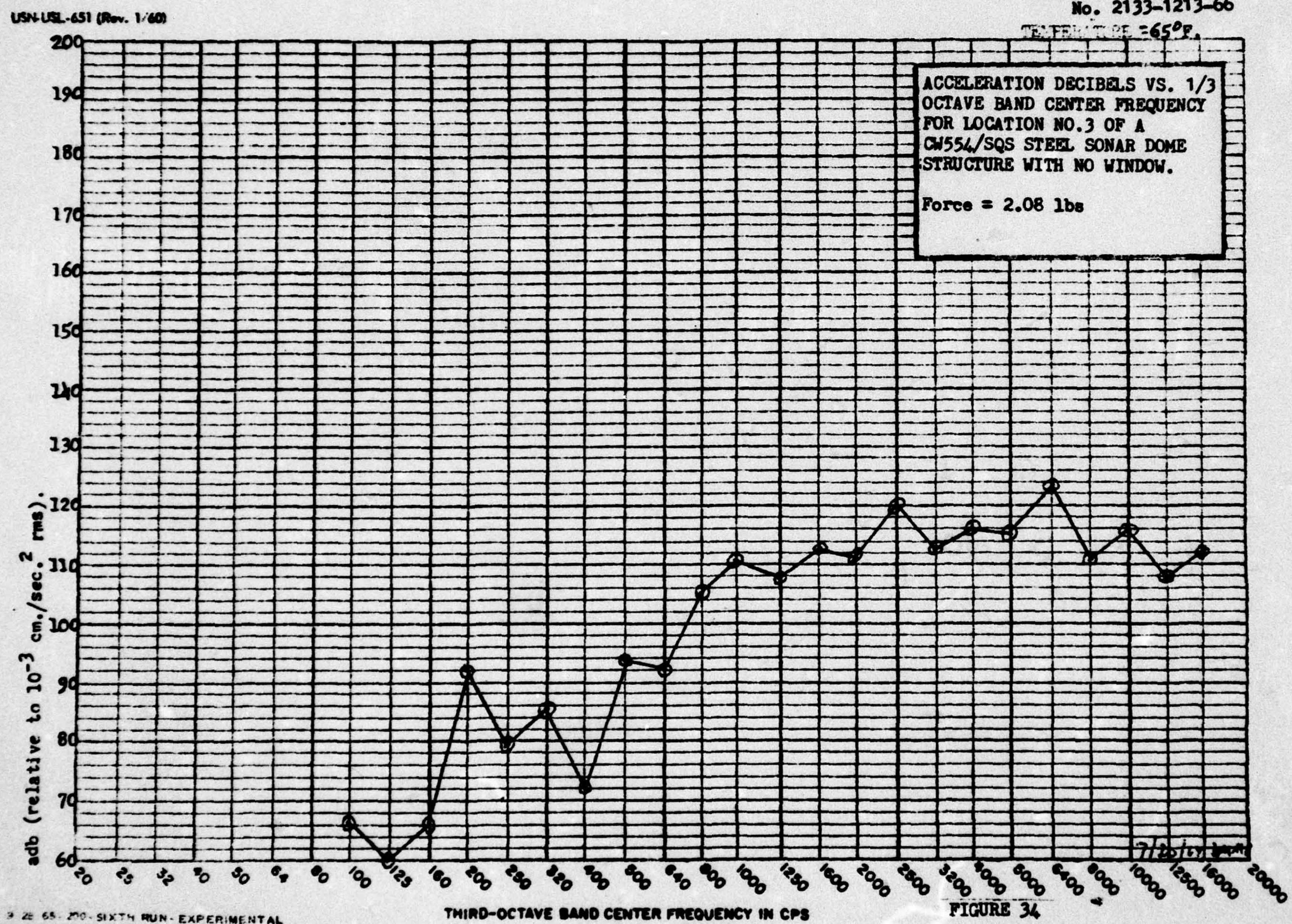

USN-USL-651 (Rev. 1/60)
TEMPERATURE =65°F.
ACCELERATION DECIBELS VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO.3 OF A CW554/SQS STEEL SONAR DOME STRUCTURE WITH NO WINDOW.
Force = 2.08 lbs
adb (relative to 10^-3 cm./sec.^2 rms).
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
9 28 65. 200. SIXTH RUN - EXPERIMENTAL

FIGURE 34

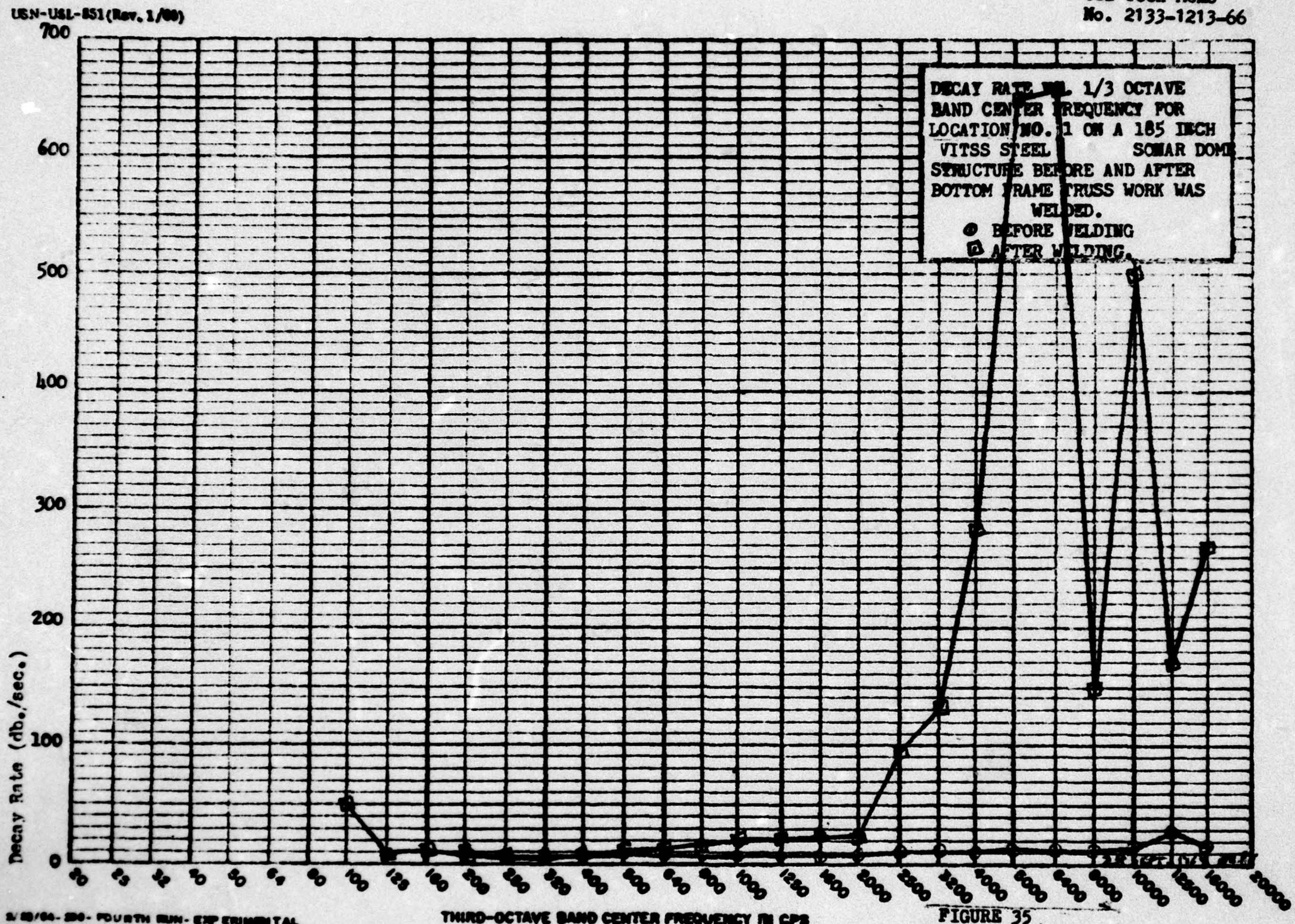

USN-USL-851(Rev. 1/60)
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 1 ON A 185 INCH VITSS STEEL SONAR DOME STRUCTURE BEFORE AND AFTER BOTTOM FRAME TRUSS WORK WAS WELDED.
BEFORE WELDING
AFTER WELDING.
Decay Rate (db./sec.)
700
600
500
400
300
200
100
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
2/59/64- 250- FOURTH RUN- EXPERIMENTAL

FIGURE 35

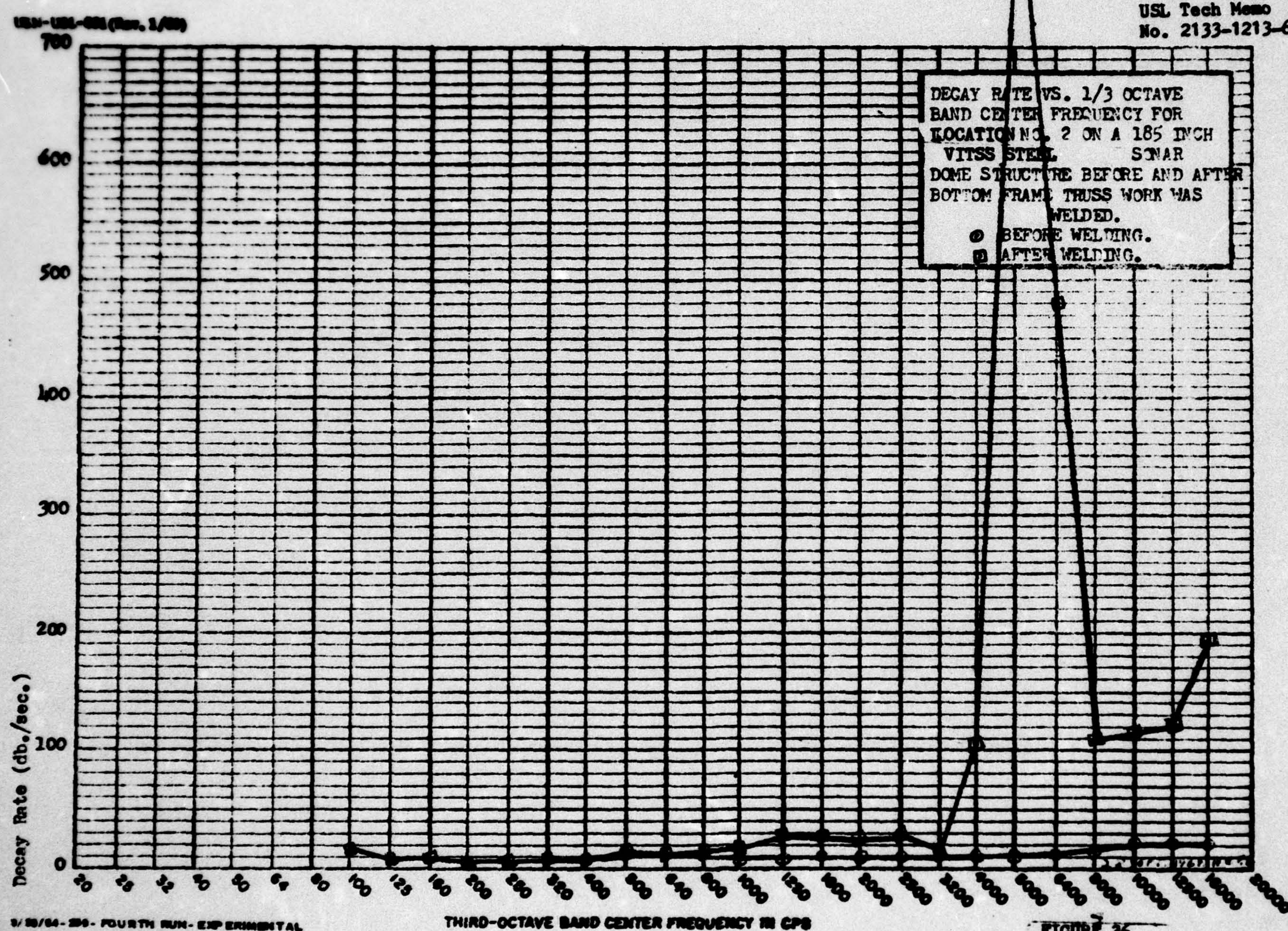

700
600
500
400
300
200
100
0
Decay Rate (db./sec.)
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 ON A 185 INCH VITSS STEEL SONAR DOME STRUCTURE BEFORE AND AFTER BOTTOM FRAME TRUSS WORK WAS WELDED.
BEFORE WELDING.
AFTER WELDING.
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
FOURTH RUN- EXPERIMENTAL

FIGURE 36

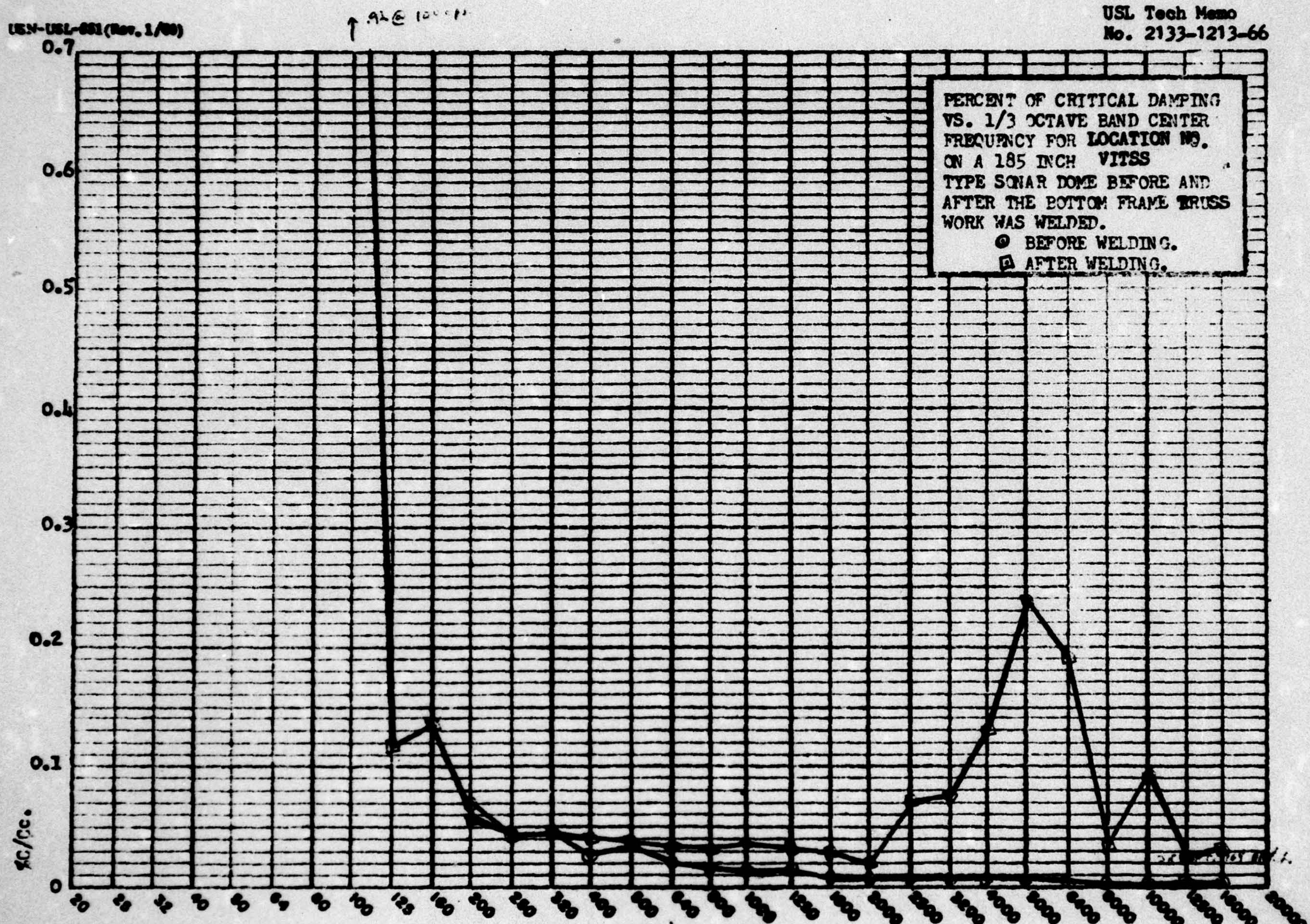

USN-USL-681(Rev. 1/60)
↑ .92 @ 100
PERCENT OF CRITICAL DAMPING
VS. 1/3 OCTAVE BAND CENTER
FREQUENCY FOR LOCATION NO.
ON A 185 INCH VITSS
TYPE SONAR DOME BEFORE AND
AFTER THE BOTTOM FRAME TRUSS
WORK WAS WELDED.
BEFORE WELDING.
AFTER WELDING.
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
%C/Cc.
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
3/30/64-200- FOURTH RUN- EXPERIMENTAL

FIGURE 37

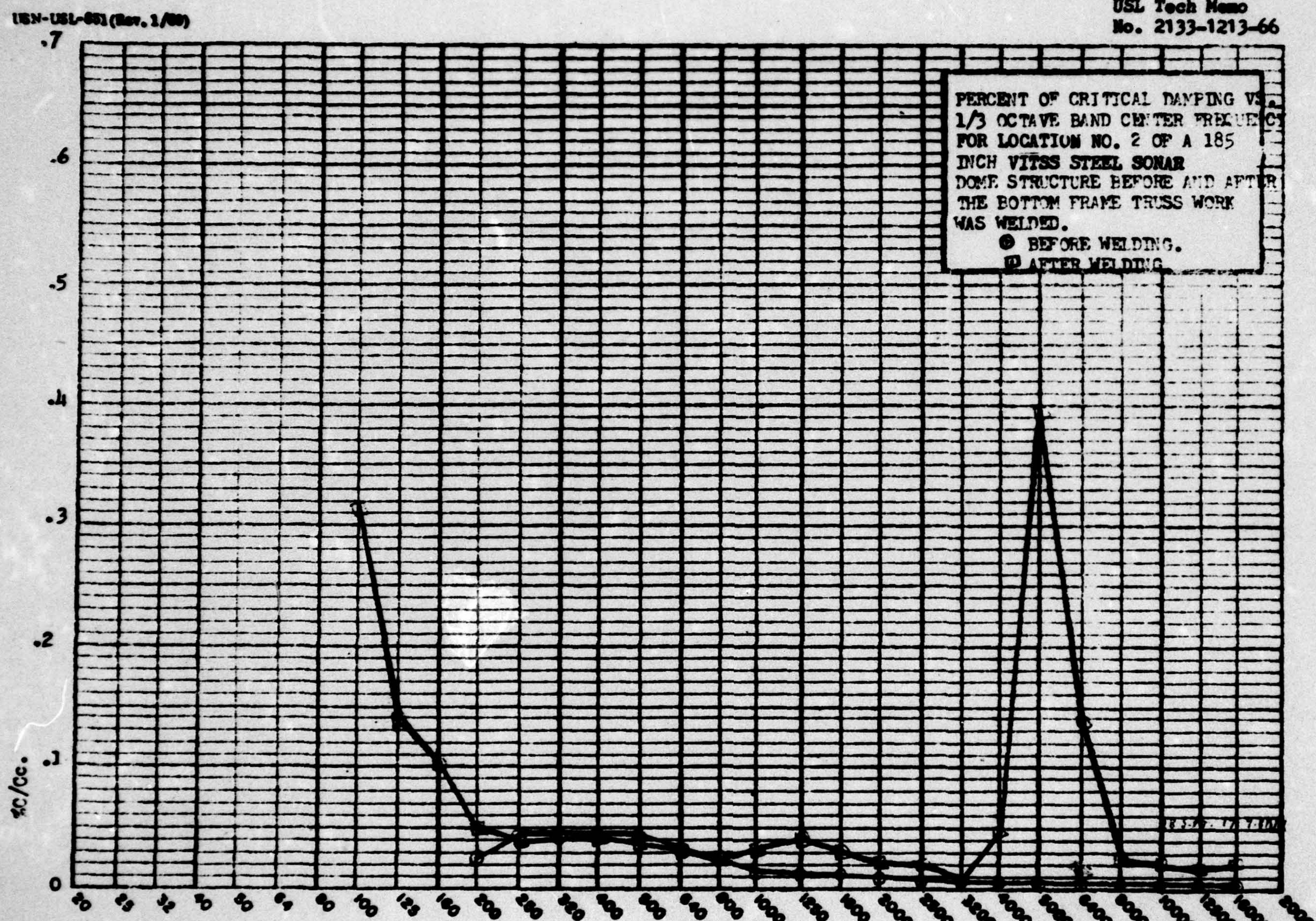

USN-USL-851(Rev.1/60)
%C/Cc.
.7
.6
.5
.4
.3
.2
.1
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
PERCENT OF CRITICAL DAMPING VS.
1/3 OCTAVE BAND CENTER FREQUENCY
FOR LOCATION NO. 2 OF A 185
INCH VITSS STEEL SONAR
DOME STRUCTURE BEFORE AND AFTER
THE BOTTOM FRAME TRUSS WORK
WAS WELDED.
BEFORE WELDING.
AFTER WELDING.
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
3/30/64-200- FOURTH RUN- EXPERIMENTAL

FIGURE 38

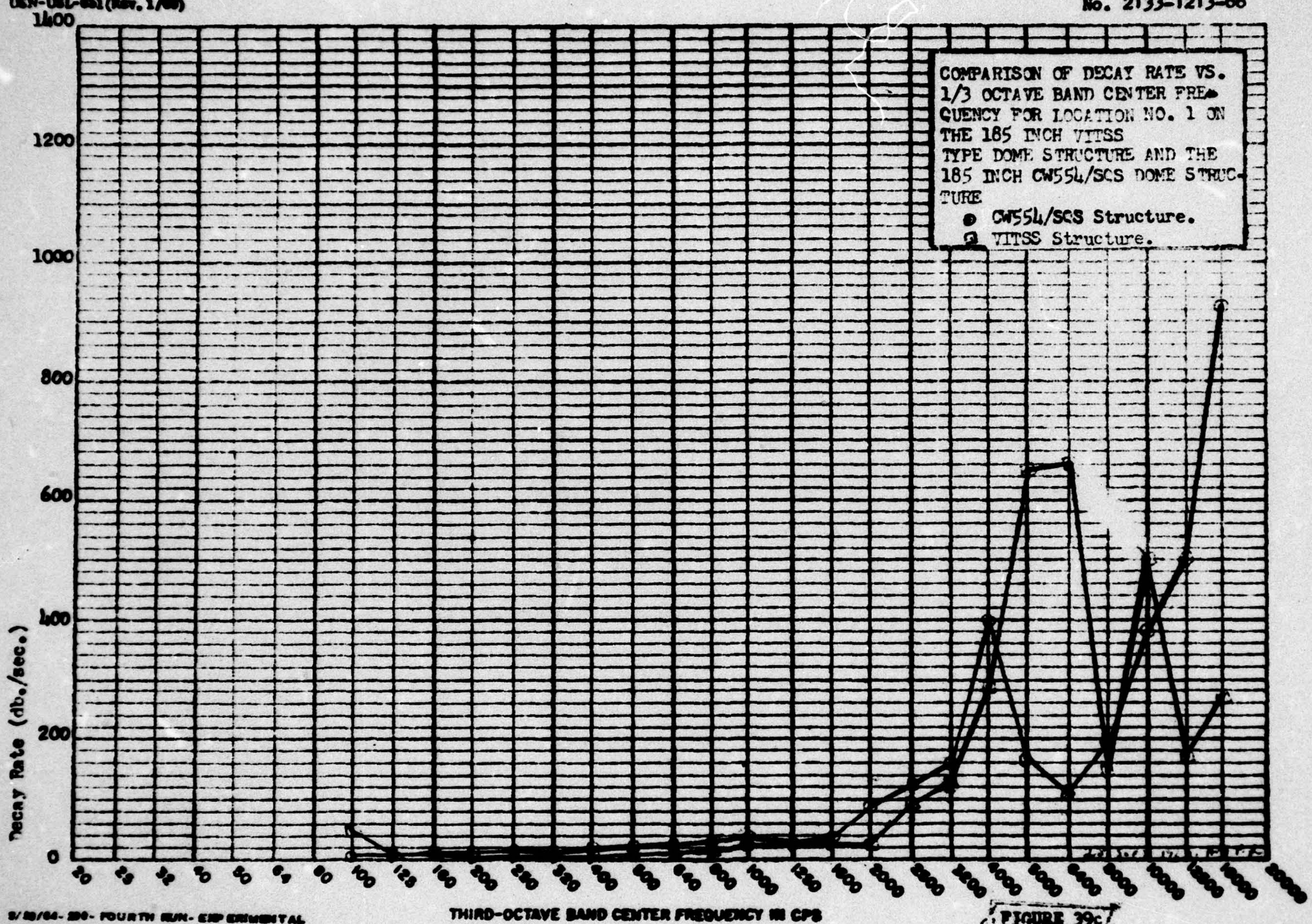
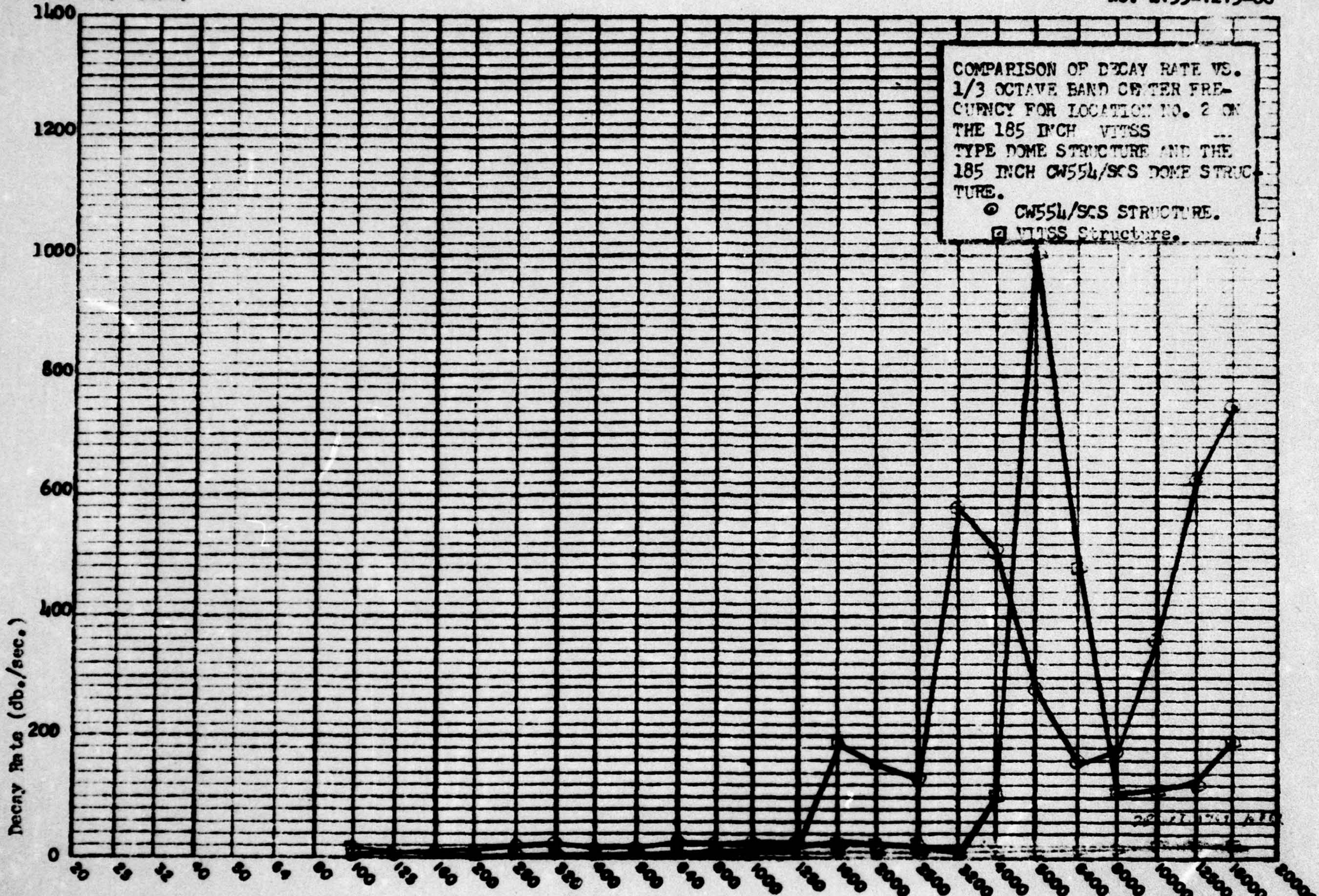

USN-USL-651(Rev. 1/60)
COMPARISON OF DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 1 ON THE 185 INCH VITSS TYPE DOME STRUCTURE AND THE 185 INCH CW554/SCS DOME STRUCTURE
CW554/SCS Structure.
VITSS Structure.
Decay Rate (db./sec.)
0
200
400
600
800
1000
1200
1400
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
9/28/64- 250- FOURTH RUN- EXPERIMENTAL

FIGURE 39c

USN-USL-651 (Rev. 1/60)



FOURTH RUN-EXPERIMENTAL

FIGURE 40

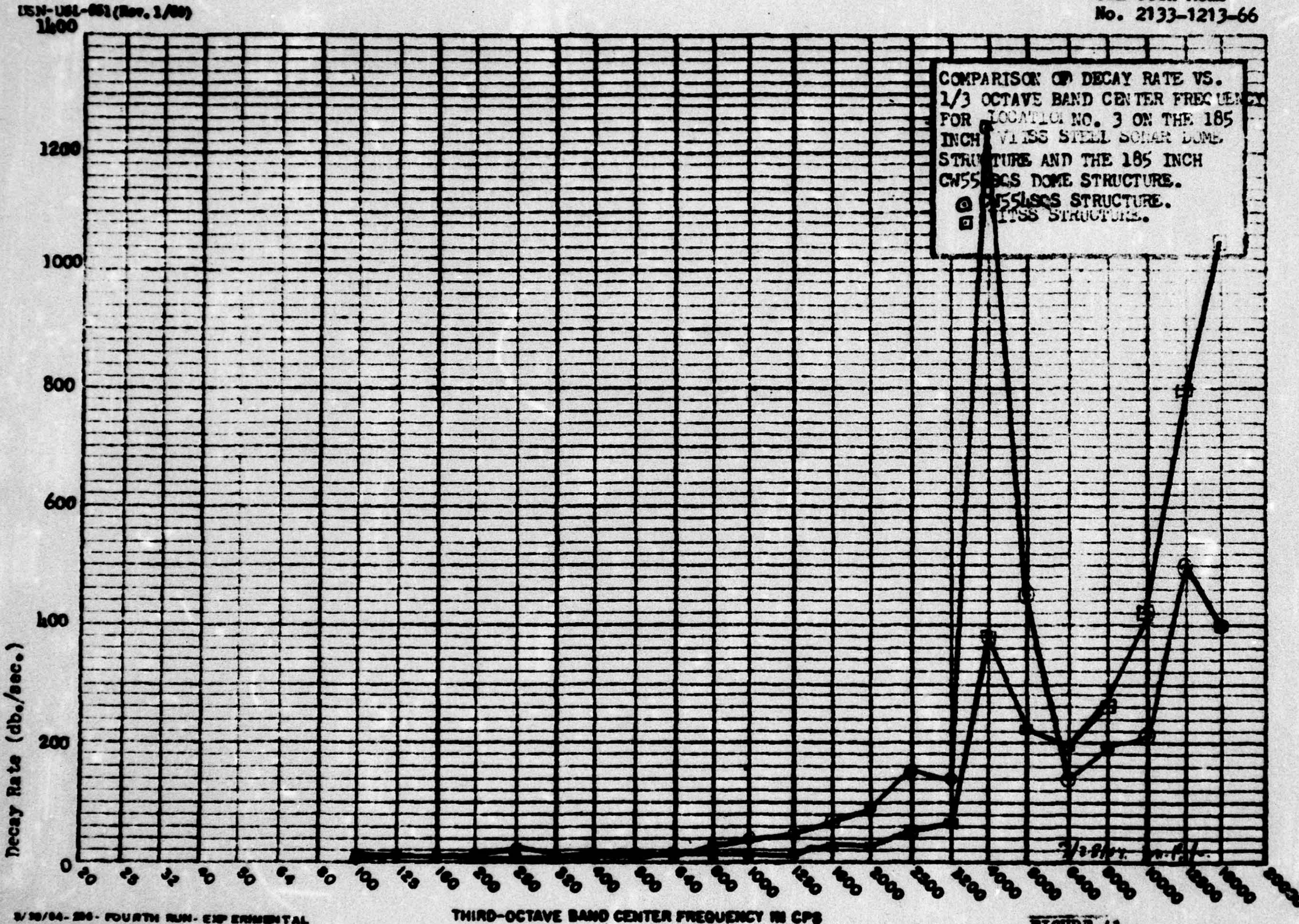

USN-USL-651(Rev. 1/60)
COMPARISON OF DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 3 ON THE 185 INCH VITSS STEEL SONAR DOME STRUCTURE AND THE 185 INCH CW55LSGS DOME STRUCTURE.
CW55LSGS STRUCTURE.
VITSS STRUCTURE.
Decay Rate (db./sec.)
0
200
400
600
800
1000
1200
1400
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
9/30/64-250-FOURTH RUN-EXPERIMENTAL

FIGURE 43

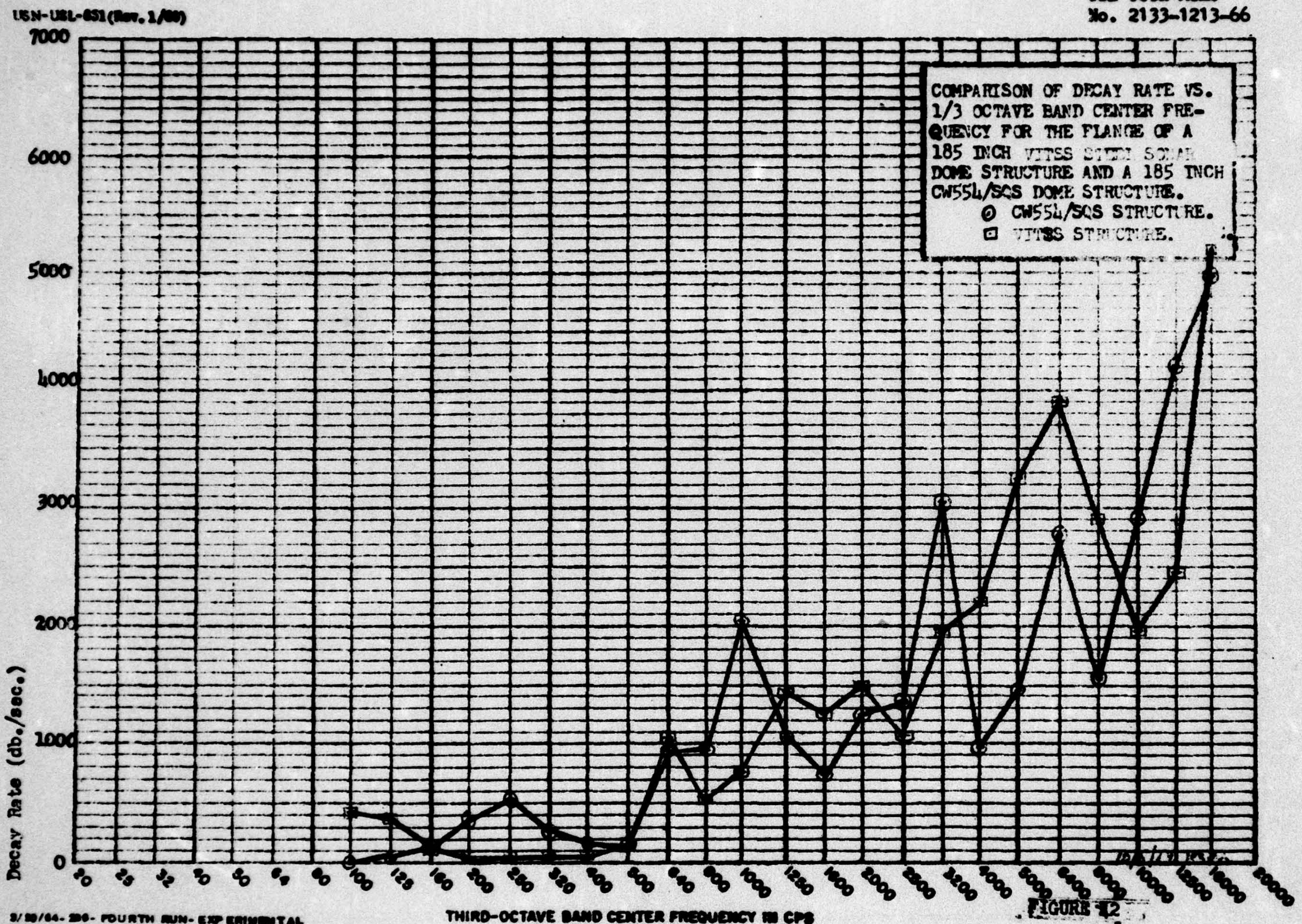

USN-USL-651(Rev. 1/60)
COMPARISON OF DECAY RATE VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR THE FLANGE OF A 185 INCH VITSS STEEL SONAR DOME STRUCTURE AND A 185 INCH CW554/SQS DOME STRUCTURE.
CW554/SQS STRUCTURE.
VITSS STRUCTURE.
Decay Rate (db./sec.)
7000
6000
5000
4000
3000
2000
1000
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
3/30/64-200- FOURTH RUN- EXPERIMENTAL

FIGURE 12

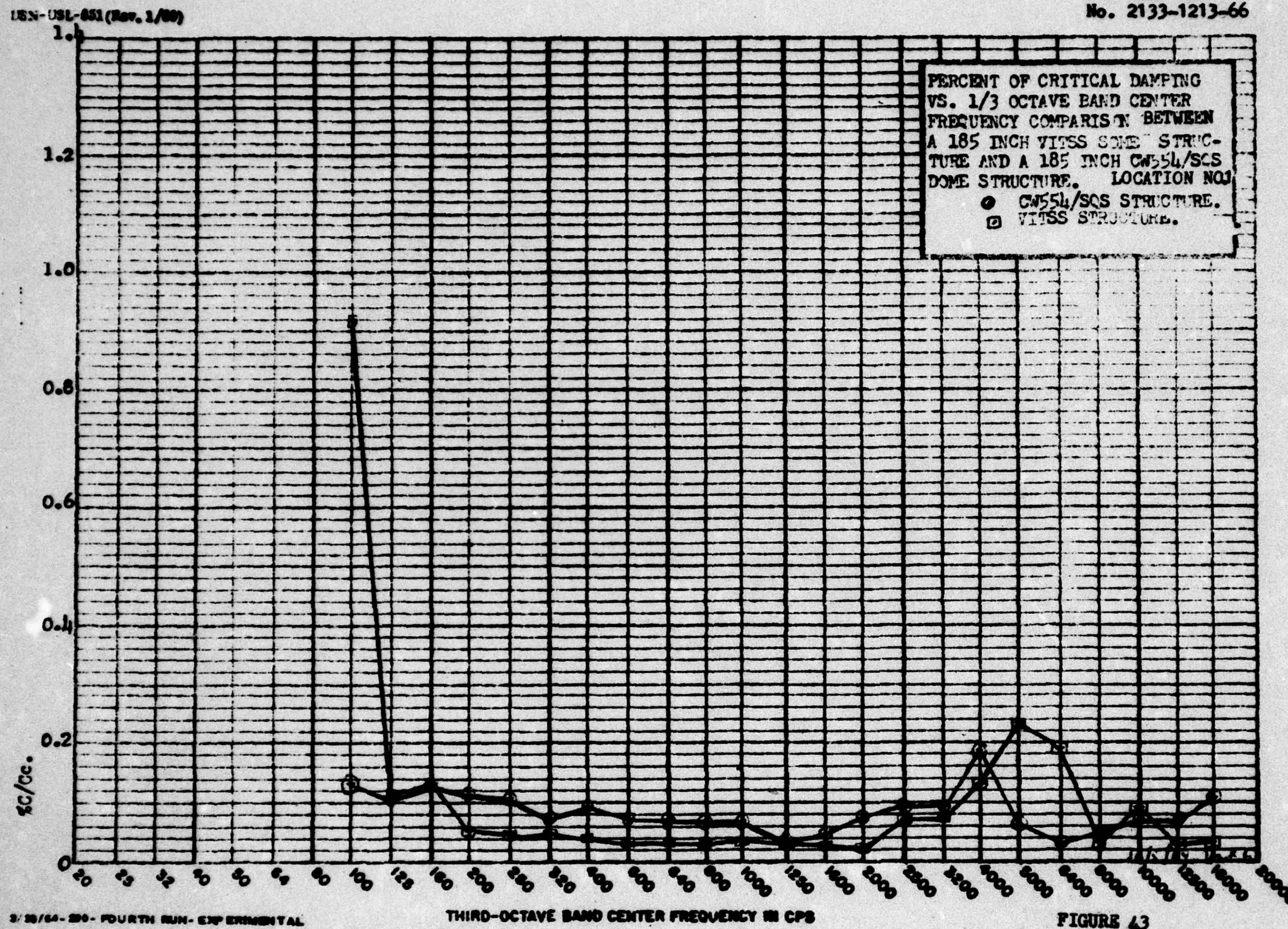

USN-USL-651 (Rev. 1/60)
PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY COMPARISON BETWEEN A 185 INCH VITSS DOME STRUCTURE AND A 185 INCH CW554/SQS DOME STRUCTURE. LOCATION NO1
CW554/SQS STRUCTURE.
VITSS STRUCTURE.
%C/Cc.
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
3/30/64-250- FOURTH RUN- EXPERIMENTAL

FIGURE 43

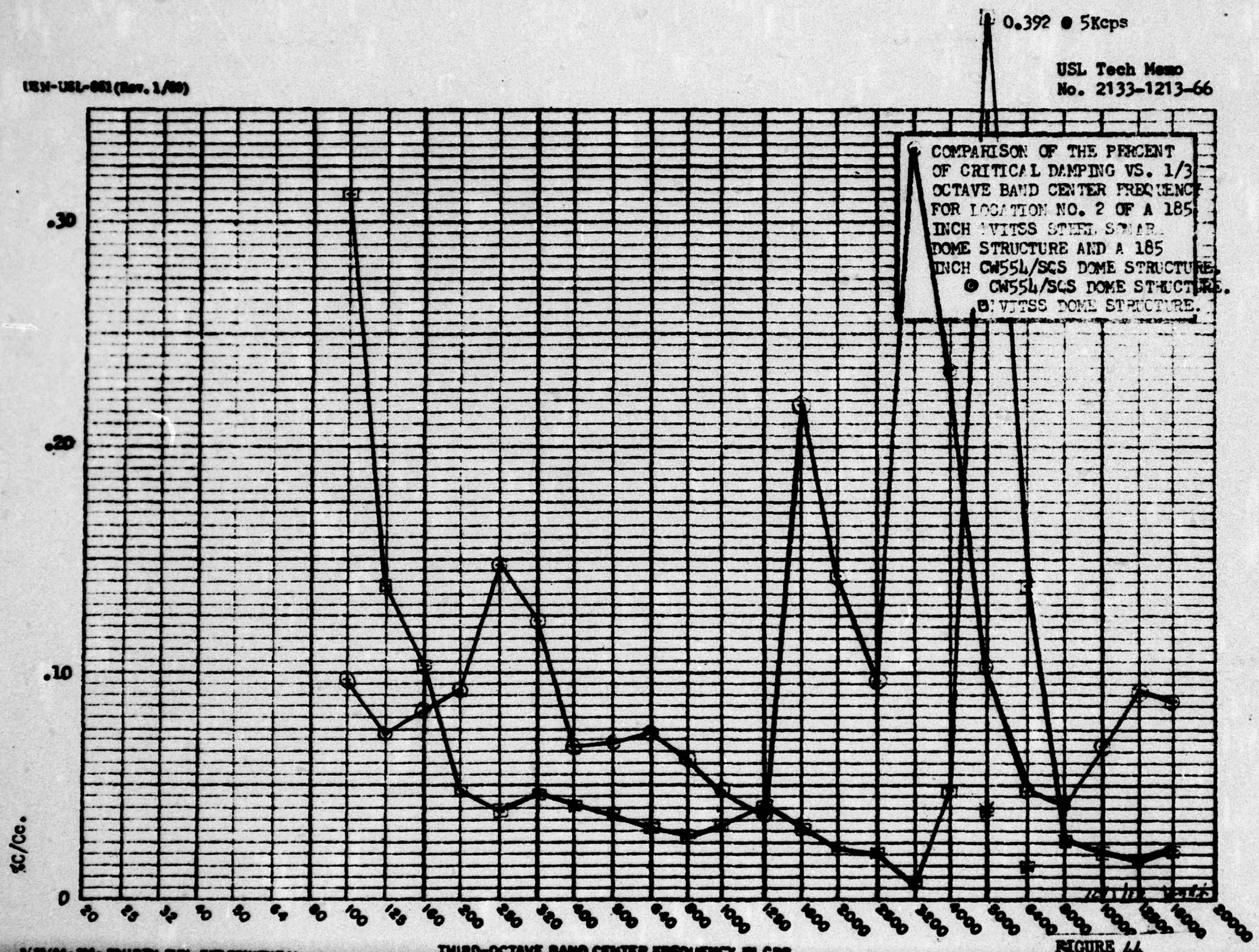
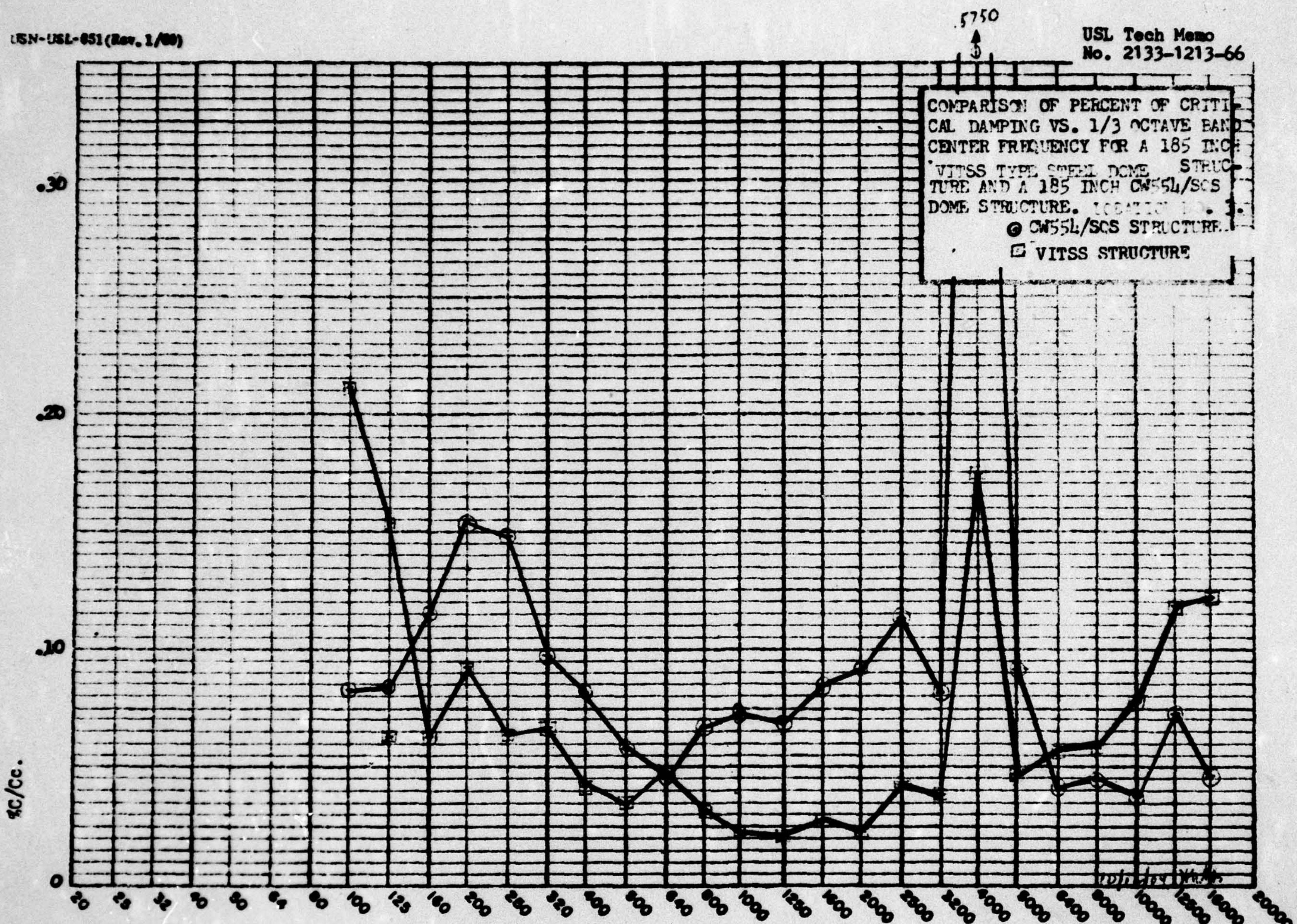

0.392 @ 5Kcps
COMPARISON OF THE PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 OF A 185 INCH VITSS STEEL SONAR DOME STRUCTURE AND A 185 INCH CW554/SCS DOME STRUCTURE.
CW554/SCS DOME STRUCTURE.
VITSS DOME STRUCTURE.
.30
.20
.10
0
%C/Cc.
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS

FIGURE 44

USN-USL-651(Rev. 1/60)



3/30/64 - 250 - FOURTH RUN - EXPERIMENTAL

FIGURE 45.

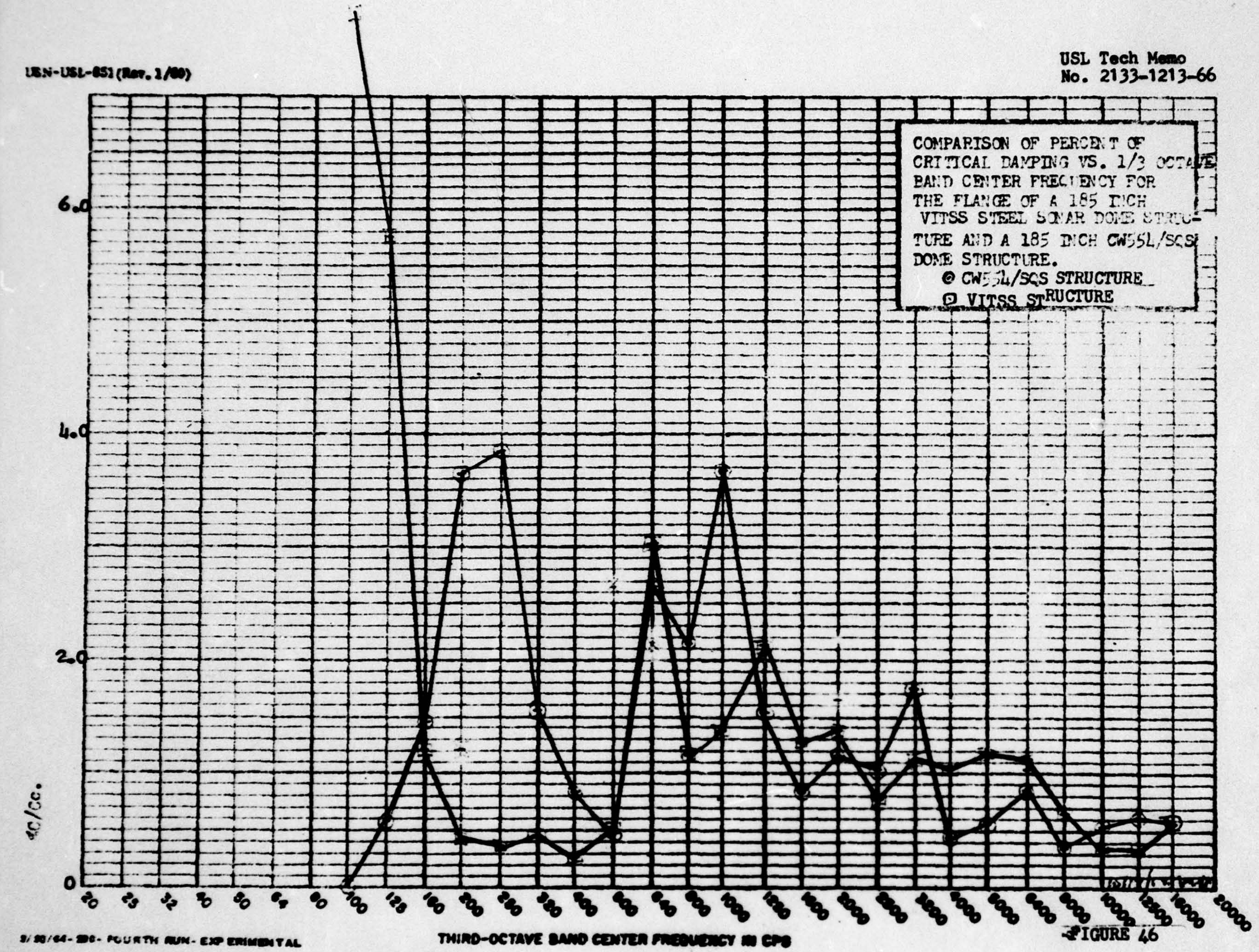

USN-USL-851 (Rev. 1/60)
COMPARISON OF PERCENT OF CRITICAL DAMPING VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR THE FLANGE OF A 185 INCH VITSS STEEL SONAR DOME STRUCTURE AND A 185 INCH CW55L/SQS DOME STRUCTURE.
CW55L/SQS STRUCTURE
VITSS STRUCTURE
6.0
4.0
2.0
0
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
8/28/64 - 206 - FOURTH RUN - EXPERIMENTAL
4C/CC.

FIGURE 46

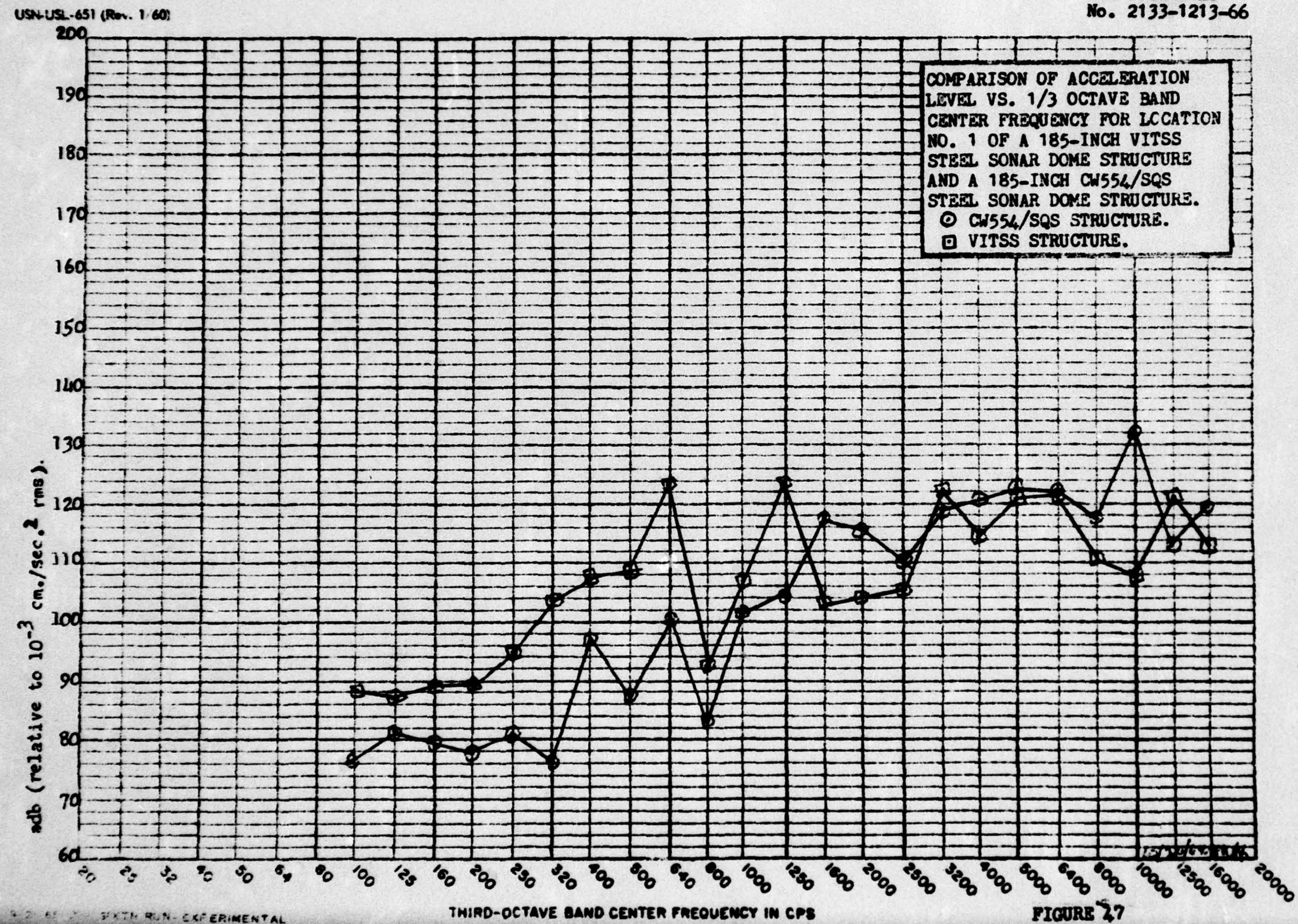

USN-USL-651 (Rev. 1/60)
COMPARISON OF ACCELERATION LEVEL VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 1 OF A 185-INCH VITSS STEEL SONAR DOME STRUCTURE AND A 185-INCH CW554/SQS STEEL SONAR DOME STRUCTURE.
⊙ CW554/SQS STRUCTURE.
⊡ VITSS STRUCTURE.
adb (relative to 10⁻³ cm./sec.² rms).
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
20 25 32 40 50 64 80 100 125 160 200 250 320 400 500 640 800 1000 1250 1600 2000 2500 3200 4000 5000 6400 8000 10000 12500 16000 20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
SIXTH RUN - EXPERIMENTAL

FIGURE 27

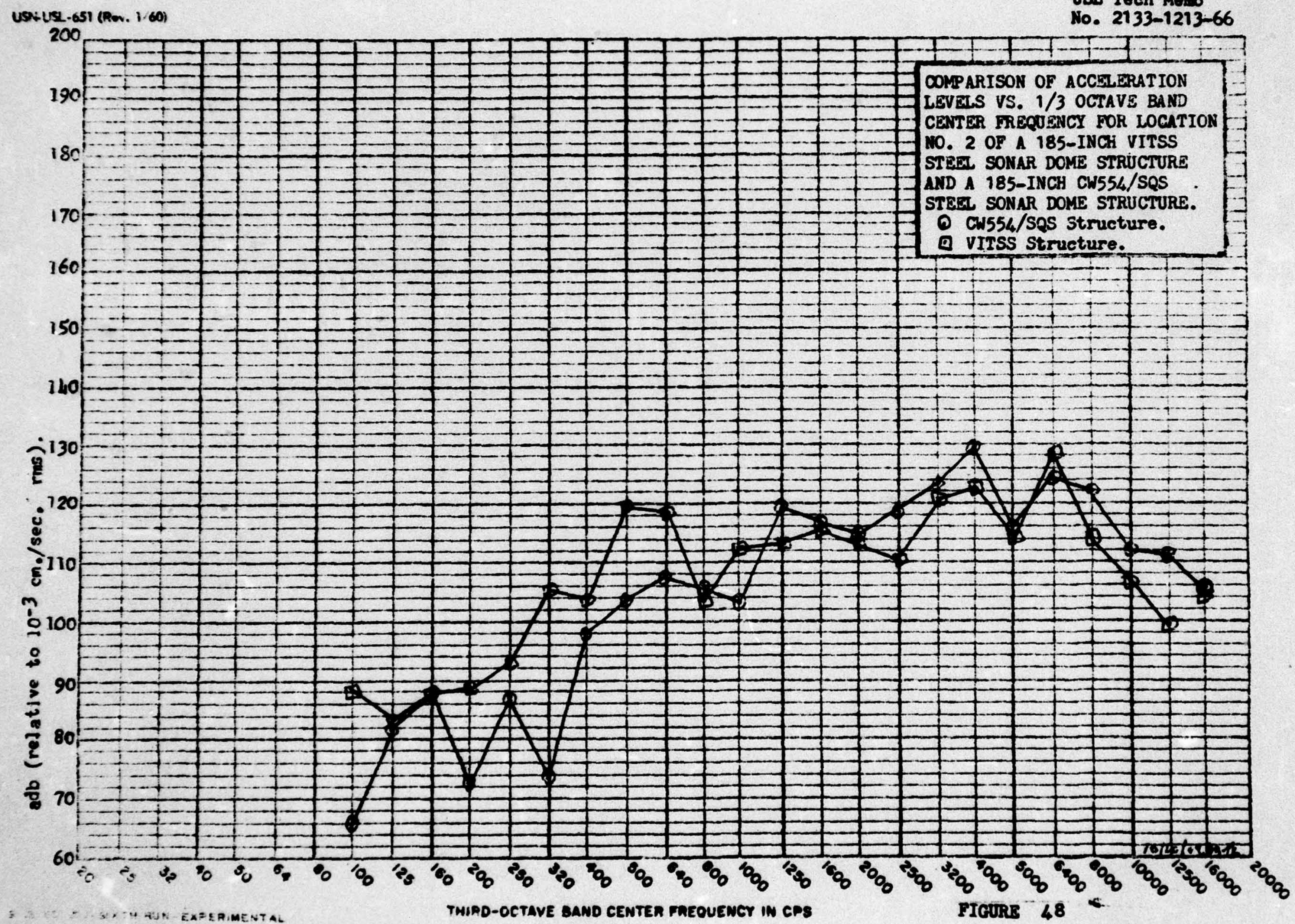

USN-USL-651 (Rev. 1/60)
COMPARISON OF ACCELERATION LEVELS VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 2 OF A 185-INCH VITSS STEEL SONAR DOME STRUCTURE AND A 185-INCH CW554/SQS STEEL SONAR DOME STRUCTURE.
CW554/SQS Structure.
VITSS Structure.
adb (relative to 10^{-3} cm./sec.^{2} rms).
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
EXPERIMENTAL

FIGURE 48

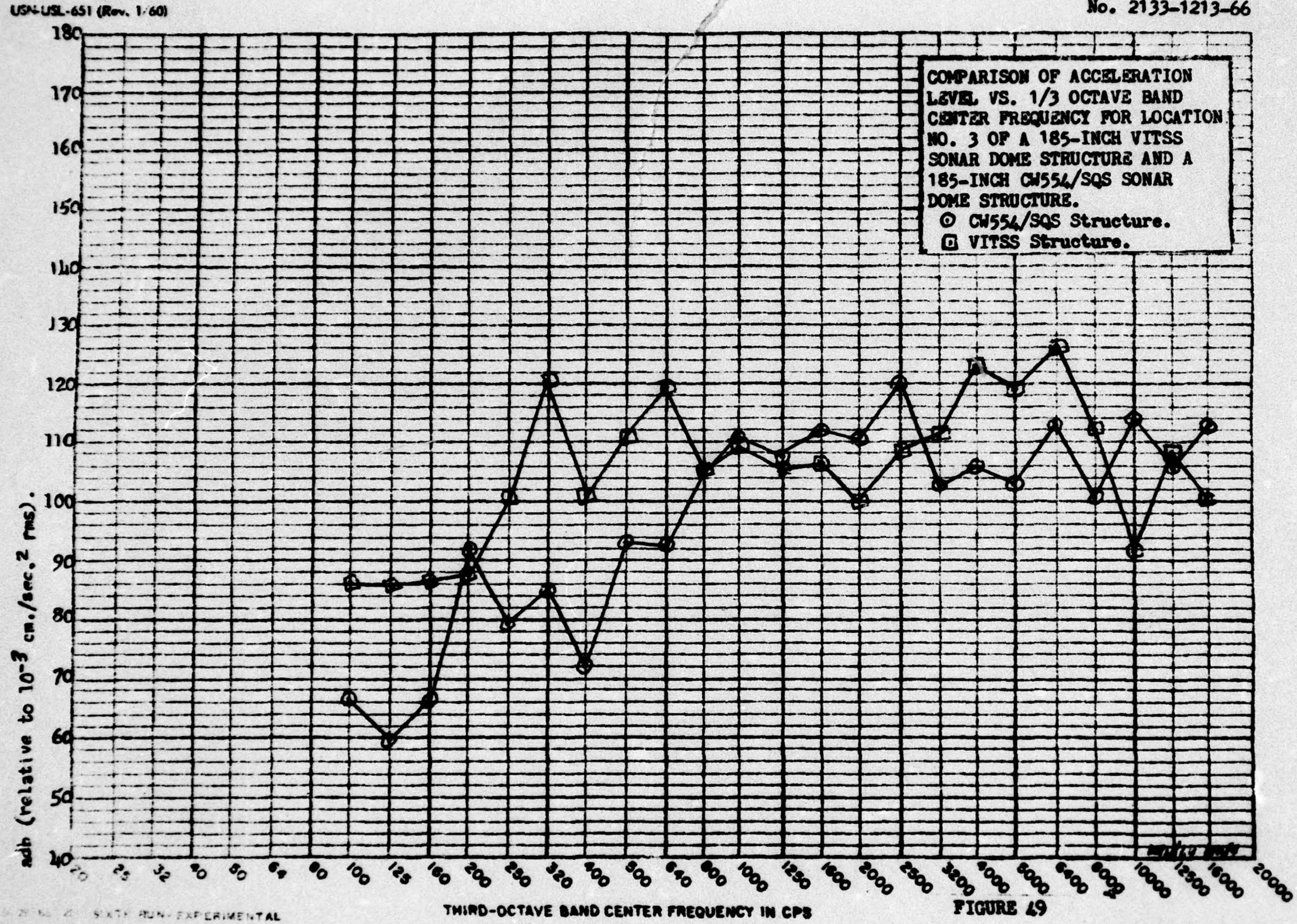

USN-USL-651 (Rev. 1/60)
COMPARISON OF ACCELERATION LEVEL VS. 1/3 OCTAVE BAND CENTER FREQUENCY FOR LOCATION NO. 3 OF A 185-INCH VITSS SONAR DOME STRUCTURE AND A 185-INCH CW554/SQS SONAR DOME STRUCTURE.
⊙ CW554/SQS Structure.
⊡ VITSS Structure.
adb (relative to 10-3 cm./sec.2 rms).
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
20
25
32
40
50
64
80
100
125
160
200
250
320
400
500
640
800
1000
1250
1600
2000
2500
3200
4000
5000
6400
8000
10000
12500
16000
20000
THIRD-OCTAVE BAND CENTER FREQUENCY IN CPS
SIXTH RUN-EXPERIMENTAL

FIGURE 49